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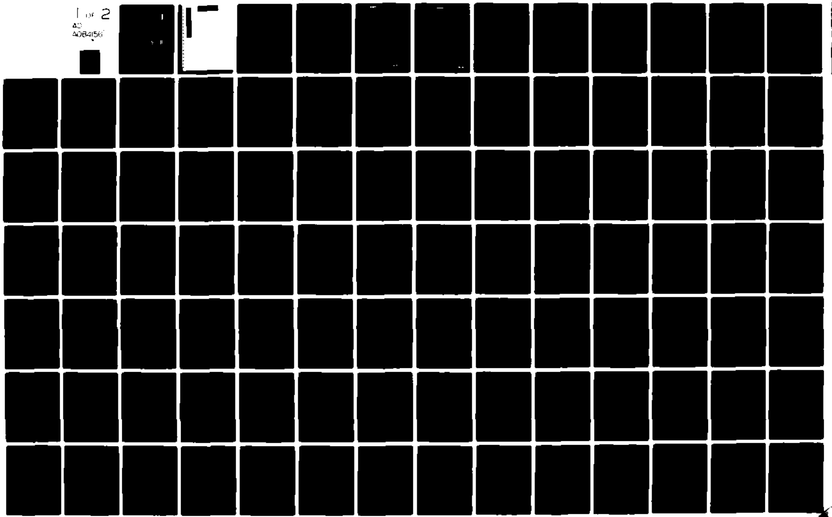

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Philadelphia District
North Atlantic Division

Engineering and Economic Analysis of Federally Authorized Delaware River Anchorages

March 1974

Tippetts-Abbett-McCarthy-Stratton
Engineers and Architects New York

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The purpose of this study is to provide the Philadelphia District of the Corps of Engineers with a detailed analysis of the benefits to be gained through the improvement of the six federally authorized anchorages along the Delaware River, updating of the costs associated with these improvements, alternative schemes for improving the anchorages, if warranted, and preliminary benefit-to-cost ratios for the improvements and alternatives considered. The six anchorages considered in this study are Reedy Point, Deepwater Point, Marcus Hook, Mantua Creek, Gloucester

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and Port Richmond Anchorages.

The work includes projecting future vessel traffic along the Delaware River; studying the costs and likelihood of accidents, especially those involving oil spills; determining the costs of operational delays and cargo lightering are a consequence of anchorage conditions; considering the possible impacts a proposed deepwater port off Delaware Bay and improvements to the Chesapeake and Delaware Canal on anchorage usuage; and preparing conclusions on the feasibility of improving the anchorages.

The information and data on which the analysis is based were obtained by means of a questionnaire, personal interviews, and research in relevant literature.

A questionnaire consisting of three parts (a copy of which is contained in Appendix A) was sent to 59 Delaware River shipowners and their agents, of whom 36 (61 per cent) responded. The questinnnaire provided information on number, type, size and destination of vessel traffic along the Delaware River for 1972 as well as information on anchorage usage, operational delays, lightering from anchorages, and projected fleet composition.

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March 31, 1974

Mr. Robert Kaighn
U.S. Army Corps of Engineers
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2nd and Chestnut Streets
Philadelphia, Pennsylvania

Dear Mr. Kaighn:

In accordance with our agreement dated April 19, 1973, we transmit herewith our report entitled, Engineering and Economic Analysis of Federally Authorized Delaware River Anchorages. This report summarizes the work carried out under Phase I and reflects comments on our draft report made by the Corps and local interests.

The study included review of relevant literature, dicussions with local interests and the distribution of a questionnaire concerning movements of vessels on the Delaware River. From this information, forecasts of vessel traffic and anchorage use were developed. The benefits and preliminary costs associated with improving the anchorages were then developed and compared. Our conclusions on improving the anchorages and recommendations on the need for further study are presented at the beginning of the report.

We should like to thank you and other members of the staff of the Philadelphia District of the Corps of Engineers for your assistance in assembling material for use in the report. We should also like to express our appreciation for the assistance afforded us in this study by the U.S. Coast Guard, the Pilots Association of the

Bay and River Delaware, the Philadelphia Maritime Exchange, the American Institute of Merchant Shipping and numerous other representatives of the shipping industry.

Very truly yours,

TIPPETTS-ABBETT-McCARTHY-STRATTON

Thomas J. Fratar

Thomas J. Fratar

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ENGINEERING AND ECONOMIC ANALYSIS OF FEDERALLY AUTHORIZED DELAWARE RIVER ANCHORAGES

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CONCLUSIONS

The analysis described in this report was carried out under two assumptions concerning the construction of a deepwater port off the east coast of the United States. If a deepwater port is built by 1980, it is assumed that all crude oil destined for the Delaware River refineries would be off loaded at the deepwater port and transferred to the refineries by pipeline. If a deepwater port is not built off the east coast, it is assumed that some of the crude oil would be transshipped from deep-water ports in Canada, the Caribbean or the Gulf and be transported to the Delaware River refineries in smaller vessels. The remainder would be shipped directly to Delaware Bay. Movements of petroleum product vessels, iron ore carriers and general cargo vessels are assumed to be unaffected by the existence of a deepwater port.

The results of our analysis of Mantua Creek Anchorage indicate that although safety hazards attend the use of the anchorage by vessels exceeding 500 feet in length, the estimated costs of the improvements required to substantially reduce the hazards exceed the benefits estimated to result thereby. The comparison of costs and benefits indicate that under the most optimistic circumstances outlined in Chapters 5, 6 and 7, the benefit-cost ratio would only reach 0.65. As mentioned in Chapter 6, the dredging costs used in developing this ratio for Mantua Creek Anchorage do not reflect the current higher costs of spoil disposal which may cause an increase in the actual costs of improving Mantua Creek Anchorage of as much as 50 or 100%, thereby reducing further the benefit cost ratio.

At Marcus Hook Anchorage, there appears to be ample justification for improving the anchorage as outlined in Chapter 6, if a deepwater port is not built. Our study indicates that if environ-

mental benefits are not considered, the benefit cost ratio would range from 1.25 to 1.84, depending on the assumptions used concerning safety improvements. The inclusion of environmental benefits would result in a further increase in the benefit-cost ratio. If a deepwater port is operational by 1980, our analysis indicates a benefit cost ratio that would approach 0.73.

These ratios were developed assuming both Mantua Creek and Marcus Hook Anchorages would be improved. If, however, Mantua Creek Anchorage is not improved, while Marcus Hook is, more vessels would use Marcus Hook than was estimated in preparing the ratio. The increased use of Marcus Hook Anchorage would result in a 25 to 30 per cent increase in the benefits attributable to improving this anchorage, under both assumptions regarding the presence of a deepwater port. On this basis, the benefit-cost ratio for the Marcus Hook Anchorage improvements, assuming a deepwater port is built, is estimated to increase to about 1.0.

The loss of life and injury that would occur as a result of accidents in the anchorages has not been quantified and is not reflected in the benefit-cost ratio. This factor should, however, be considered in making decisions concerning improvements to the anchorages.

Our study revealed that improvements to the other four federally authorized anchorages; Reedy Point, Deepwater Point, Gloucester Point and Port Richmond anchorages are not justified at this time, under either assumption concerning the existence of a deepwater port.

The results of our questionnaire and discussions with Pilots and U.S. Coast Guard officials reveal that improvements to anchorages in Delaware Bay may be needed. Increased lightering

activity at Big Stone Beach Anchorage by vessels attempting to reduce draft may be causing congestion and an unsafe condition. Lightering activity at Big Stone Beach will increase rapidly until 1980, whether a deepwater port is developed or not.

RECOMMENDATIONS

Based on the above conclusions, the following are recommended:

1. Phase II of this study, which involves refinement of the estimated costs of improvements and benefit-cost ratios, should be prepared for Marcus Hook Anchorage.

2. Further study of improving Mantua Creek, Reedy Point, Gloucester and Port Richmond Anchorages is not recommended.

3. The problems associated with the soft river bottom at Deepwater Point Anchorage should be investigated.

4. The adequacy of the Delaware Bay anchorage areas, particularly Big Stone Beach Anchorage, should be evaluated.

CHAPTER 1

INTRODUCTION

OBJECTIVE OF THE STUDY

The purpose of this study is to provide the Philadelphia District of the Corps of Engineers with a detailed analysis of the benefits to be gained through the improvement of the six federally authorized anchorages along the Delaware River, updating of the costs associated with these improvements, alternative schemes for improving the anchorages, if warranted, and preliminary benefit-to-cost ratios for the improvements and alternatives considered. The six anchorages considered in this study are Reedy Point, Deepwater Point, Marcus Hook, Mantua Creek, Gloucester and Port Richmond Anchorages.

CONDUCT OF THE STUDY

The work includes projecting future vessel traffic along the Delaware River; studying the costs and likelihood of accidents, especially those involving oil spills; determining the costs of operational delays and cargo lightering that are a consequence of anchorage conditions; considering the possible impacts of a proposed deepwater port off Delaware Bay and improvements to the Chesapeake and Delaware Canal on anchorage usage; and preparing conclusions on the feasibility of improving the anchorages.

The information and data on which the analysis is based were obtained by means of a questionnaire, personal interviews, and research in relevant literature.

A questionnaire consisting of three parts (a copy of which is contained in Appendix A) was sent to 59 Delaware River shipowners and their agents, of whom 36 (61 per cent) responded. The questionnaire pro-

vided information on the number, type, size and destination of vessel traffic along the Delaware River for 1972 as well as information on anchorage usage, operational delays, lightering from anchorages, and projected fleet composition. A summary of the information obtained from the responses, tabulated by computer, is included in Appendix B. Of the total number of questionnaires distributed, 15 were sent to oil companies and their agents, of which 13 were returned; 2 were sent to dry bulk carriers, both of which were returned; and the remainder were sent to general cargo shippers and their agents, of which 21 out of 42 responded. A list of the concerns responding to the questionnaire is contained in Appendix C.

Personal interviews were conducted with shippers, port and terminal officials, and experts in fields relevant to the study. A list of the persons consulted is contained in Appendix D. Finally, current literature was searched primarily for information on trends in petroleum consumption, the economic and environmental impact of oil spills, accident risk, and future vessel characteristics. A list of the books, reports, and magazines referred to is included in Appendix E.

CHAPTER 2

THE DELAWARE RIVER

GENERAL INFORMATION

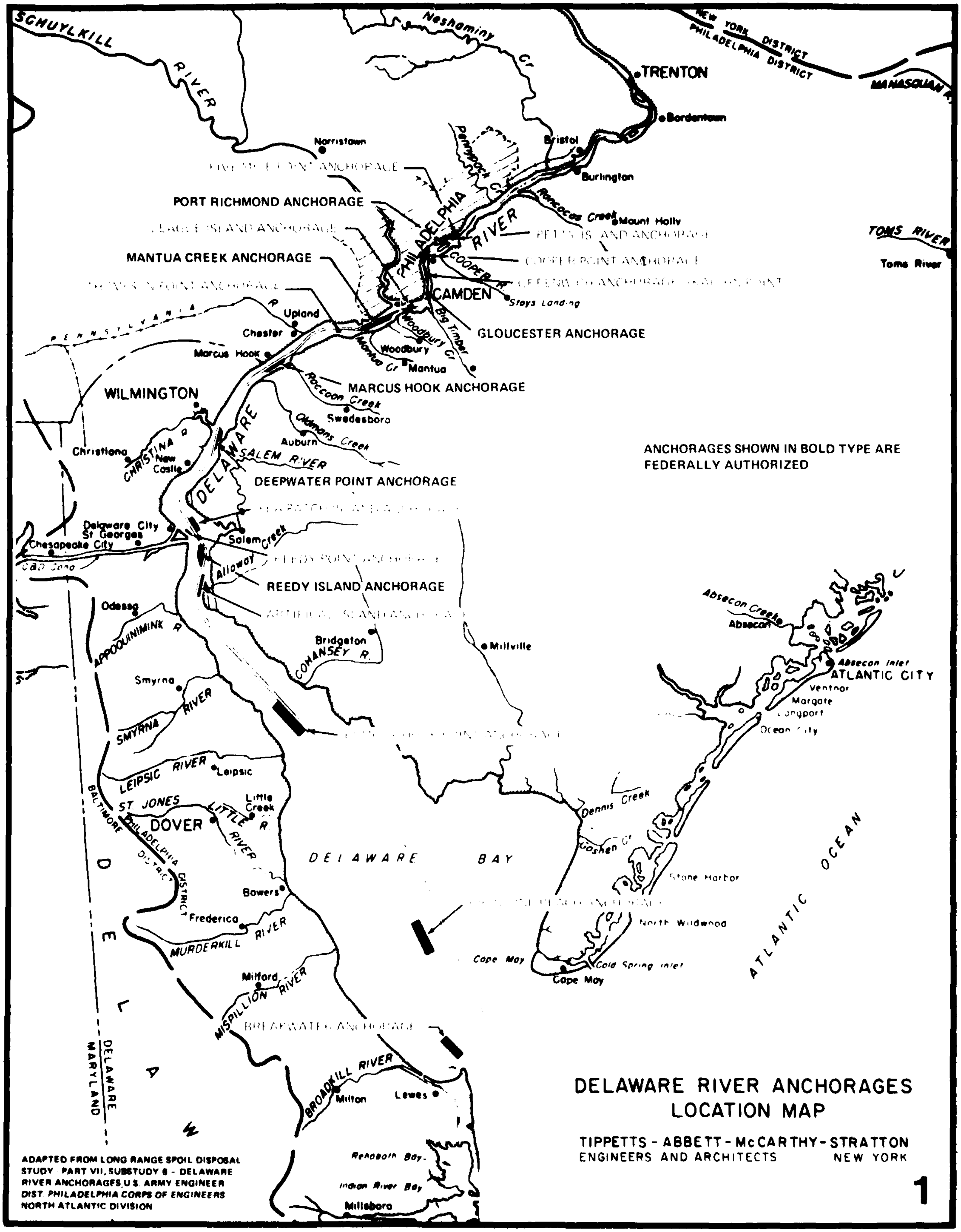
The reach of the Delaware River under consideration extends from deep water in Delaware Bay to Five Mile Point in north Philadelphia. A mean tidal range of 6.0 feet is experienced at Philadelphia and 5.8 feet is experienced at the head of the Bay. The river has a normal tidal current velocity of less than 3 knots.

The lower stretch of the river is bordered by three states -- Delaware, New Jersey and Pennsylvania -- with several principal cities and towns located along the channel, including: Wilmington and Claymont, Delaware; Camden, Gloucester, Paulsboro, Penns Grove, and Deepwater Point, New Jersey; and Philadelphia, Chester and Marcus Hook, Pennsylvania. Over 100,000 jobs in the Delaware Valley are directly dependent upon port activity, and the ports along the River directly and indirectly generate a total income in excess of two billion dollars annually.

The Federal Government presently maintains an improved channel and six anchorages along the river (see Figure 1). The first project for the systematic improvement of the River, with the objective of affording a safe and efficient waterway for the size and number of vessels expected to use the facility within the reasonably foreseeable future, was authorized by the Congress in 1885. Additional projects for improving the waterway have since been authorized by the Congress.

THE PRESENT PROJECT

The present project for the Delaware River provides authorization for a channel depth of 40 feet (42 feet in rock) 800 feet wide



DELAWARE RIVER ANCHORAGES
LOCATION MAP

TIPPETTS - ABBETT - McCARTHY - STRATTON
ENGINEERS AND ARCHITECTS NEW YORK

1

from Delaware Bay to the Philadelphia Naval Base and 400 feet wide along the west side of the channel from the Naval Base to Allegheny Avenue. The east side of the channel from the Naval Base to Allegheny Avenue is authorized at a depth of 37 feet for a width of 600 feet.

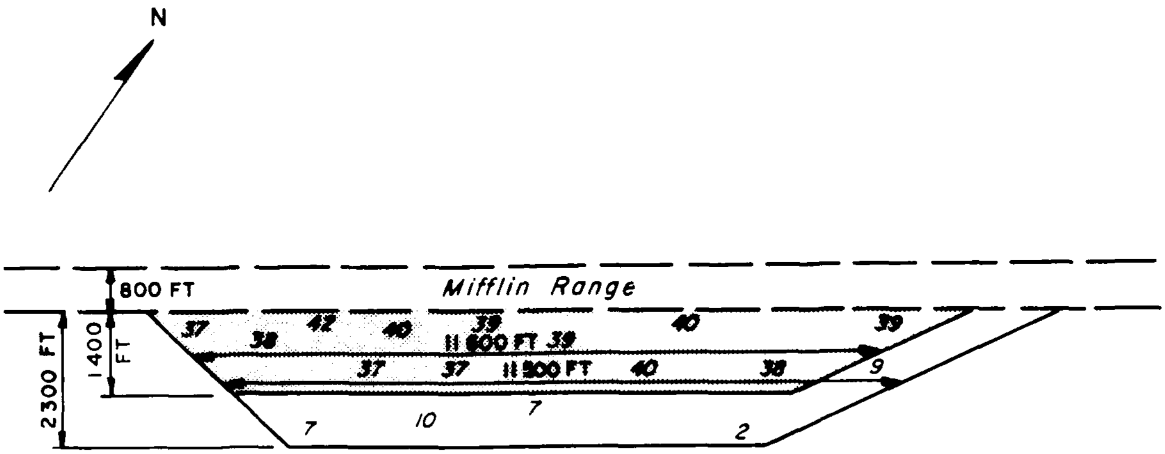
Federal legislation in 1958 authorized the deepening to 40 feet and enlargement of Marcus Hook and Mantua Creek anchorages to 2300 feet wide with mean lengths of 13,650 feet and 11,500 feet respectively. Figure 2 is an illustration of the authorized anchorages. Marcus Hook and Mantua Creek would have a capacity for anchoring six and five 600 to 800 foot vessels respectively under the authorized dimensions.

The same authorization in 1958 provided for the creation of new anchorages at Deepwater Point and Reedy Point. The anchorages would each have a depth of 40 feet and a width of 2300 feet with Deepwater to have a mean length of 5200 feet and Reedy Point a mean length of 8000 feet. A plan of the authorized dimensions for each of the two anchorages is shown in Figure 3. The new Deepwater Point Anchorage would have an anchoring capacity of two 600 to 800 foot vessels, and the new Reedy Point anchorage would permit three 600 to 800 foot vessels to anchor.

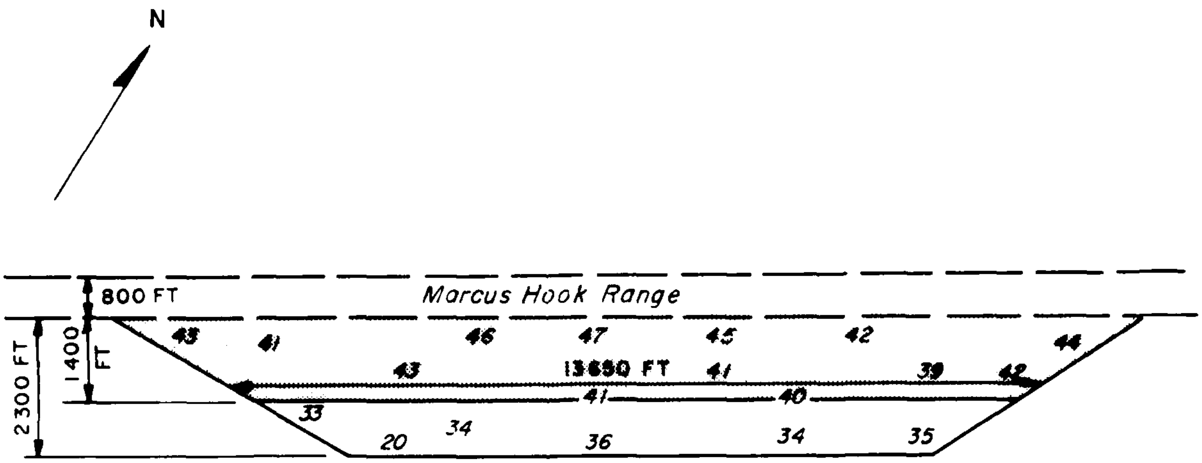
Previous authorizations include provisions for Gloucester anchorage with a depth of 30 feet, a length of 3500 feet and a mean width of 400 feet and provisions for Port Richmond anchorage, with an authorized depth of 37 feet, a length of 6400 feet, and mean width 500 feet. Table 1 summarizes the authorized dimensions of the six anchorages.

ACTUAL CONDITIONS

Marcus Hook Anchorage was originally dredged to its authorized dimension but was only maintained for a mean length of 13,650 feet at a depth of 40 feet for a width of 1400 feet. The remaining 900 foot width of



MANTUA CREEK ANCHORAGE



MARCUS HOOK ANCHORAGE

LEGEND

Existing Anchorage

Authorized Anchorage

34 Soundings in Feet at Mean Low Water

ACTUAL AND AUTHORIZED DIMENSIONS MANTUA CREEK AND MARCUS HOOK ANCHORAGES

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0 3000 FEET

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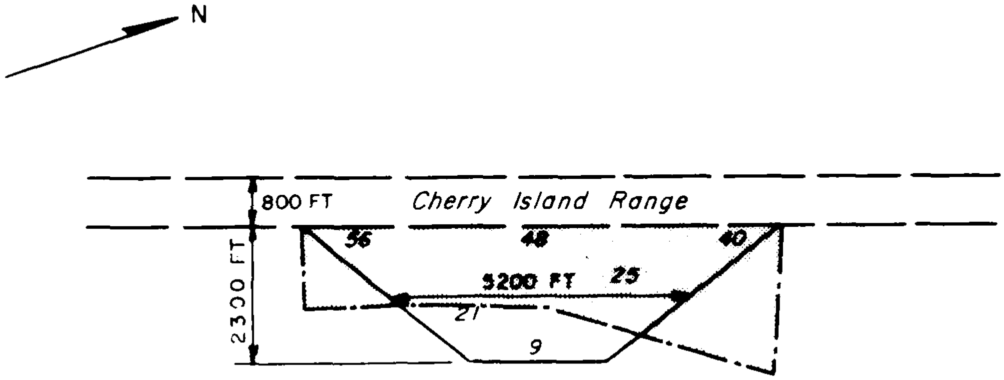
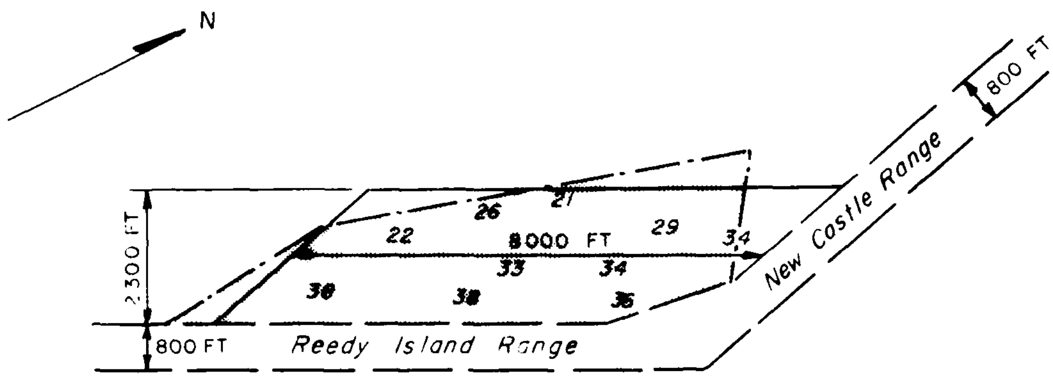


DEEPWATER POINT ANCHORAGE



REEDY POINT ANCHORAGE

LEGEND

Existing Anchorage

Authorized Anchorage

34 Soundings in Feet of Mean Low Water

ACTUAL AND AUTHORIZED DIMENSIONS DEEPWATER POINT AND REEDY ISLAND ANCHORAGES

TIPPETTS-ABBETT-McCARTHY-STRATTON
ENGINEERS AND ARCHITECTS NEW YORK

0 2000 FEET

3

TABLE 1

SUMMARY OF ANCHORAGE CHARACTERISTICS

Name of Anchorage	AUTHORIZED Length (Feet)	AUTHORIZED Width (Feet)	AUTHORIZED Depth (Feet)	AUTHORIZED Capacity	ACTUAL Length (Feet)	ACTUAL Width (Feet)	ACTUAL Depth (Feet)	ACTUAL Capacity (Vessels)
Marcus Hook	13,650 (mean)	2,300	40	6 [1]	13,650 (mean)	1,400	40	6 [1]
Mantua Creek	11,500 (mean)	2,300	40	5 [1]	11,600 (mean)	1,400	37	5 [1]
Deepwater	5,200 (mean)	2,300	40	2 [1]	8,200	1,750 (mean)	35	1 [2]
Reedy Point	8,000 (mean)	2,300	40	3 [1]	8,000	2,200 (mean)	35	5 [2]
Gloucester	3,500	400 (mean)	30	[3]	3,500	400 (mean)	35	[3]
Port Richmond	6,400	500 (mean)	37	[3]	6,400	500 (mean)	35	[3]

[1] Vessel size: 600 to 800 feet

[2] Vessel size: 450 to 500 feet

[3] For use primarily by general cargo vessels awaiting berth

Source: U.S. Department of the Army, Corps of Engineers, Philadelphia District, Long Range Spoil Disposal Study, 1969

Marcus Hook has not been maintained. Mantua Creek is being maintained at a depth of 37 feet for a mean length of 11,600 feet and a width of 1400 feet. At present, vessels now using Mantua Creek are restricted to a maximum draft of 33 feet at low tide.

Deepwater and Reedy Point anchorages are only designated in natural waters (see Figure 3), each with depths of approximately 35 feet. Deepwater is 8200 feet long, varying in width from 1100 to 2500 feet. Reedy Point has a length of 8000 feet and an average width of 2200 feet. While Deepwater has a capacity of anchoring one 500 foot vessel, pilots advise that poor soil conditions make it difficult for an anchor to hold. A total of five 450 to 500 foot vessels are able to anchor at Reedy Point.

Both Gloucester and Port Richmond anchorages have a depth of 35 feet. A summary of the actual anchorage dimensions for all six of the anchorages is also presented in Table 2.

CHAPTER 3

COMMERCE AND VESSEL TRAFFIC

GENERAL

This chapter presents projections of oil and iron ore commerce and vessel traffic on the Delaware River for the period from 1975 to 2025. The forecast for the period from 1975 to 2000 draws heavily on the Corps of Engineers' report, Interim Report: Atlantic Coast Deep Water Port Facilities Study 1973, and the Economic and Engineering Analysis for Delivery of Refined Petroleum Products by Van Houten Associates, 1973 which we have reviewed and consider reasonable.

It is assumed that total waterborne commerce to the Delaware River area will not be significantly affected by the existence of a deepwater port. The forecast of vessel movements, however, will be affected by the existence of a deepwater port. As a result, forecasts of vessel movements were made under two assumptions concerning the existence of a deepwater port; one assuming a deepwater port is built off the east coast by 1980 and one assuming no east coast deepwater port is developed.

This forecast was prepared before the full effect of the current energy crisis was felt. As a result, changed conditions may result in a lower level of petroleum imports than is forecast here.

CRUDE OIL

Historical Crude Oil Receipts

Seventy per cent of all crude oil imports now coming into the middle Atlantic region enter by way of Delaware Bay. Table 2 indicates the levels of waterborne receipts of crude oil to the Delaware River Area

TABLE 2

Delaware River Crude Oil Receipts: 1962 - 1972
(Short Tons)

	Receipts (1,000 Tons)		
Year	Imports	Coastwise	Total
1962	24,292	14,926	39,218
1963	24,745	13,768	38,513
1964	24,071	15,069	39,140
1965	23,948	14,672	38,620
1966	24,937	14,205	39,142
1967	20,649	19,714	40,363
1968	26,551	17,049	43,600
1969	28,176	18,545	46,721
1970	20,971	26,643	47,614
1971	24,433	22,563	46,996
1972	34,160	11,479	45,639

Source: U.S. Department of the Army, Corps of Engineers, Waterborne Commerce of the U.S., 1962-1972.

over the past 10 years. This indicates that an increasing amount of crude oil demand is being met by imports rather than coastwise receipts, which mostly come from the Gulf Coast. Imports remained fairly constant from 1962 to 1967 but fluctuated widely from 1967 to 1972 with an average annual growth rate of 6.5 per cent during that period. Coastwise receipts have declined over this period.

The major factor determining the volume of crude imported to the Delaware Bay area is the refining capacity of the region. The seven Delaware River refineries constitute the second largest concentration of refining capacity for any single U.S. port, and together with the three refineries on New York/New Jersey channels account for 90 per cent of the total refining capacity on the East Coast. In 1970, these ten refineries received over 50 per cent of the total oceanborne imports of crude oil in the U.S.

Forecast of Crude Oil Receipts

The demand for energy in the United States is increasing at a time when domestic production of crude oil is leveling off. Between the years 1970 and 2000 it is estimated that the U.S. demand for crude oil will increase at an average annual rate of 3.5 per cent while domestic production will increase annually at only a little more than 1.0 per cent. This deficit will necessarily have to be made up by increased foreign imports of crude oil.

The Corps of Engineers in their report, Interim Report: Atlantic Coast Deep Water Port Facilities Study, projected crude oil receipts to the Delaware River to increase at an average annual rate of approximately 14% between 1970 and 1980, decreasing to a rate of 3.5% per year between 1980 and 2000. The Corps assumed that present refineries will be expanded to the maximum capacity possible at their existing locations and

TABLE 3

Forecast of Crude Oil Receipts
Delaware River

(Short Tons)

Year	Receipts (1,000 Tons) Imports	Coastwise	Total
1970	20,971	26,643	47,614
1975	49,100	8,000	57,100
1980	78,500	1,000	79,500
2000	157,000		157,000
2025	200,000		200,000

Source: Corps of Engineers, Interim Report: Atlantic Coast Deep Water Port Facilities Study, 1973.
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that no new refineries will be built in the Delaware River area before the year 2000.

Based on the assumption that new energy sources will begin to relieve the demand for petroleum but will not be able to replace it as the major energy source before 2025, it is estimated that petroleum imports to the Delaware River will increase at a nominal rate of 1% per year between 2000 and 2025. This results in a projected rate of oil importation of 200,000,000 tons per year in 2025. Implicit in this projection is the assumption that at least one new refinery will be built in the Delaware River area by 2025.

In the future, even with incentives to increase production along the U.S. Gulf Coast, all of the crude oil produced in that region will be used to meet Gulf Coast and mid-continent demands. Thus, by the year 1980, virtually all shipments of Gulf Coast crude to the Delaware River area will have stopped. That source of crude will consequently be replaced by increased foreign imports as shown in Table 3. Most of the increase in crude imports are expected to come from the extensive deposits in the Persian Gulf and to a lesser extend, North Africa.

REFINED PETROLEUM PRODUCTS

Historical Refined Products Receipts

Table 4 presents the Delaware River receipts of residual oil and other refined petroleum products for the period from 1962 to 1972. This indicates that total receipts of refined products has increased more rapidly since 1968 than for the period preceding it, indicating that the increase in Delaware River refinery capacity has not kept up with increasing demands for refined products. Imports of refined products have mostly come from refineries in the Caribbean area while coastwise receipts now arrive from refineries in the Gulf Coast area.

TABLE 4

Delaware River Receipts of Residual Oil and
Other Refined Petroleum Products
1962 - 1972
(Short Tons)

	Receipts (1,000 Tons)		
Year	Imports	Coastwise	Total
1962	3,041	3,743	6,784
1963	3,246	3,937	7,183
1964	3,279	3,542	6,821
1965	3,730	3,645	7,375
1966	3,590	3,995	7,585
1967	4,340	3,424	7,764
1968	5,305	3,734	9,039
1969	5,925	4,258	10,183
1970	7,362	5,153	12,515
1971	6,100	5,468	11,568
1972	5,717	6,304	12,021

Source: U.S. Department of the Army, U.S. Corps of Engineers, Waterborne Commerce of the U.S., 1962-1972

Forecast of Refined Petroleum Product Receipts

The forecast of refined product receipts was developed by first considering the projected total demand for petroleum products for the Northeast Region of the United States. To determine waterborne imports of refined products to the Northeast Region it is necessary to eliminate the contributions made by waterborne receipts of crude oil that are refined in Northeast area refineries and refined products received by pipeline. This results in the demand for waterborne refined products in northeast area. A percent of this northeast area demand, based on existing relationships was assumed to be the demand for refined products in the Delaware River.

The demand for petroleum products in the Northeast Region of the U.S. is projected by the Corps of Engineers to increase from 275,000,000 tons in 1970 to 385,000,000 tons in 1980 at an average annual rate of 3.75 per cent. Between 1980 and 2000 the Corps forecasts an increase at an average annual rate of 1.8% per year reaching 570,000,000 tons by 2000. It is expected that the rate of increase will drop to 1% per year for the period 2000 to 2025, resulting in an estimated 710,000 tons of refined products being imported to the Northeast Region by 2025. Estimates of crude waterborne receipts and pipeline reciepts of refined products for the northeast region were eliminated from these totals to obtain the total projected Northeast demand for waterborne refined products.

At present, the Delaware River area demand for residual oil is 10.0 per cent of Northeast demand, and the demand for other refined products is 7.3 per cent of Northeast demand. Since no dramatic shifts in population concentrations and industrial development are anticipated in the time frame considered, it is assumed that these relationships will continue in the future. These percentages were applied to northeast demand for waterborne refined petroleum products to arrive at the forecast of waterborne receipts of refined petroleum products for the Delaware River. The results

of this are presented in Table 5 which indicates that total refined petroleum product receipts are expected to increase at an average annual rate of 2.5 per cent from 1975 to 1980, and at 1.0 per cent annually thereafter. Total receipts should reach a maximum of 29,000,000 short tons per year by 2025.

The Corps of Engineers expects petroleum products for the Delaware Bay area to come from two sources, the Caribbean and the Gulf Coast. Initially both Caribbean and domestic sources will meet the Delaware River area requirements for residual fuel oil, while toward the end of the forecast period, this supply will be composed entirely of Caribbean imports.

TOTAL CRUDE OIL AND REFINED PETROLEUM RECEIPTS

Table 6 indicates the forecast of total crude and refined product receipts. This is merely the sum of the crude and refined cargo volumes, designed to present a total picture of waterborne petroleum receipts along the Delaware River. Total oil receipts are expected to grow 5.3% annually from 1970 to 1980, 3.1% annually between 1980 and 2000 and 1% per year between 2000 and 2025, reaching 229,000,000 short tons in 2025.

IMPACT OF DEEPWATER PORT ON PETROLEUM RECEIPTS

The development of an offshore deepwater port facility should have little impact on the total tonnages of oil shipped to Delaware Bay. While the type of vessel employed is dependent on the type of port facility used, the volume of oil received is only dependent on and limited by the refining capacity available and the local demand for petroleum products. Location of a deepwater facility elsewhere along the east coast will similarly have little impact on Delaware River tonnages as refining capacity along the Delaware River will again dictate the volume of crude oil that will enter the region.

TABLE 5

Forecast of Waterborne Receipts of Refined Products
in the Delaware River
(Short Tons)

Year	Residual Fuel Oil	Other Refined Products	Total
	Receipts (1,000 Tons)		
1970	8,000	4,100	12,100
1975	11,200	5,600	16,800
1980	12,050	6,650	18,700
2000	12,150	10,850	23,000
2025	12,150	16,850	29,000

Source: Van Houten Associates, Inc., Economic and Engineering Analysis for Delivery of Refined Petroleum Products, March 1973,
Tippetts-Abbett-McCarthy-Stratton

TABLE 6

Forecast of Total Delaware River
Waterborne Oil Receipts
(Short Tons)

	Receipts (1,000 Tons)		
Year	Crude	Refined	Total
1970	47,614	12,100	59,714
1975	57,100	16,800	73,900
1980	79,500	18,700	98,200
2000	157,000	23,000	180,000
2025	200,000	29,000	229,000

Whether a deepwater port is developed along the east coast will, however, have a definite impact on the vessel traffic along the Delaware River. If a deepwater port is developed, all waterborne crude oil to the Delaware River refineries will be off-loaded at the deepwater terminal and transported to the refineries by pipeline. This will eliminate most crude carriers from transiting the river and using the anchorages.

If a deepwater port is developed along the Gulf coast, and the crude is transhipped aboard large barges, it will have the same effect on vessel traffic as if no deepwater port were built. If the crude is moved from this port via pipeline, this will virtually eliminate waterborne crude traffic along the Delaware River and have the same effect as if a deepwater port were built along the east coast.

TANKER VESSEL TRAFFIC

Tanker traffic on the Delaware River has shown a definite trend toward utilizing deeper draft vessels and more Very Large Crude Carriers (VLCC's). Statistics of tanker movements for the past ten years are presented in Table 7. This trend toward larger vessels is expected to continue in the future as well. The number of tankers moving up the Delaware River and requiring anchorages will depend on whether a deepwater port is developed near Delaware Bay. This section presents two projections of vessel movements: one assuming a deepwater port is developed and the other assuming no deepwater port.

If a deepwater facility is operational by 1980, all crude imports would be delivered to the deep draft port by more economical VLCC's where it would then be transshipped by pipeline to local refineries. Coastwise shipments of crude oil would be reduced to a negligible amount by 1980, whether a deepwater port is developed or not, thus eliminating the smaller coastal tankers from transit along the Delaware River. Therefore, given the construction of a deepwater port off Delaware Bay after 1980,

TABLE 7

Delaware River Tanker Traffic By Vessel Size[1]

	Number of Vessels			
Year	25'-29' Draft	30'-40' Draft	VLCC	Total
1962	110	1566	7	1683
1963	93	1481	3	1577
1964	111	1382	11	1504
1965	99	1297	11	1407
1966	118	1240	15	1373
1967	108	1302	31	1441
1968	196	1560	108	1864
1969	210	1655	109	1974
1970	220	1733	98	2051
1971	206	1641	138	1985
1972	212	1428	239	1879

[1] All vessels are smaller than 150,000 DWT

Source: U.S. Department of the Army, Corps of Engineers, Waterborne Commerce of the U.S., 1962-1972

tanker movements would be reduced to only those vessels carrying refined petroleum products. It is felt that most of the refined products would arrive from refineries in the Caribbean Area. Based on ship size predictions made by the American Association of Port Authorities, it is felt that by the year 2000 product carriers would not exceed 80,000 DWT and would average 40,000 DWT. In determining the number of vessel movements, it was assumed the average size of product carriers would increase from the present level to an average of 40,000 DWT by 2000, and that the average size of these vessels would remain at 40,000 DWT between 2000 and 2025 due to the channel limitation. The estimate of Delaware River tanker traffic assuming a deepwater port is developed is presented in Table 8.

If no deepwater port is developed off the Northeast coast of the U.S., crude oil would continue to move up the Delaware River, but the nature of the vessel traffic would change. Very Large Crude Carriers would enter the naturally deep waters of the Delaware Bay and lighter into large 40,000 DWT barges for transshipment to upriver refineries. Vessels larger than 150,000 DWT would be forced to lighter their whole cargo whereas VLCC's less than 150,000 DWT would probably only lighter a portion of their cargo to reduce draft and then proceed upriver to unload the rest of the cargo. Other VLCC's would transship their cargo to smaller 40,000 DWT tankers or Barges at a deepwater port elsewhere off the Atlantic Coast or in the Caribbean Area. The 40,000 DWT vessels would steam to the Delaware Bay and up the River to the refineries.

It is believed that the great majority of these barges that would be moving from Canada or a deepwater port in the Caribbean or Gulf or lightering from the Delaware Bay would be rigidly integrated tug-barge combinations with drafts of 37 feet and lengths of 650 to 700 feet with operating characteristics similar to a 40,000 DWT tanker. Therefore, for the purpose of this study, they will be considered to have the same characteristics as a 40,000 DWT vessel.

TABLE 8

Forecast of
Delaware River Vessel Traffic
Assuming Deepwater Port

Year	Vessel Size	Number of Vessels: Crude Imports	Crude Coastwise	Refined Products	Total
	<150,000	479	1177	395	2051
1970	>150,000				
	Total	479	1177	395	2051
	<150,000	489	310	444	1243
1975	>150,000	57			57
	Total	546	310	444	1300
	<150,000	27	33	416	476
1980	<150,000				
	Total	27	33	416	476
	<150,000			344	344
2000	>150,000				
	Total			344	344
2025	<150,000			469	469
	>150,000				
	Total			469	469

Source: U.S. Department of the Army, Corps of Engineers, Interim Report: Atlantic Coast Deepwater Port Facilities Study, 1973
Tippetts-Abbett-McCarthy-Stratton

The projected tanker traffic assuming no deepwater port is presented in Table 9. The projections of crude imports and barge movements up to 2000 were obtained from the Interim Report: Atlantic Coast Deepwater Port Facilities Study, prepared by the Corps of Engineers. Between 2000 and 2025 it is assumed that vessel size distribution will remain at 2000 levels. The projection of coastwise crude movements and movements of product carriers is the same as is presented on Table 8.

IRON ORE IMPORTS

Iron ore imports through facilities along the Delaware River, from Delaware Bay to Trenton, New Jersey, have fluctuated widely over the last 10 years--ranging from a high of 15,509,000 tons in 1966 to a low of 10,044,000 tons in 1972 (Table 10). Historically, steel production has been closely related to the Gross National Product (GNP). Since 90 per cent of the iron ore imported through the Delaware River is earmarked for use in the production of steel, a similar relationship is assumed between the rate of growth of the GNP and the rate of growth of ore imports.

Considering this historical relationship between iron ore requirements, developments at competing ports and the gradual reduction in domestic production of iron ore expected in the future, the Corps of Engineers in their report, forecast imports of iron to increase at an average annual rate of increase of 1.1% per year to 17,500,000 tons by the year 2000. It has been assumed that the rate of increase of iron ore imports to the Delaware River would drop below 1% after 2000 and reach a level of 20,000,000 tons in 202r (Table 11).

The construction of a deepwater port facility in the Delaware Bay area is expected to have little effect on ore carrier operations for the time fram considered in this study. Since most iron ore imports

TABLE 9

Forecast of
Delaware River Vessel Traffic
Assuming No Deepwater Port

Year	Vessel Size	Crude Imports	Crude Coastwise	Barges	Refined Products	Total
		Number of Vessels				
	<150,000	479	1177		395	2051
1970	>150,000					
	Total	479	1177	---	395	2051
	<150,000	489	310	511	444	1754
1975	>150,000	57				57
	Total	546	310	511	444	1811
	<150,000	139	33	1506	416	2094
1980	>150,000	215				215
	Total	354	33	1506	416	2309
	<150,000	150		3222	344	3716
2000	>150,000	393				393
	Total	543		3222	344	4109
	<150,000	203		4140	469	4812
2025	>150,000	505				505
	Total	708		4140	469	5317

Source: U.S. Department of the Army, Corps of Engineers, Interim Report: Atlantic Coast Deepwater Port Facilities Study, 1973
Tippetts-Abbett-McCarthy Stratton

TABLE 10

Delaware River Iron Ore Imports: 1962 - 1972

(Source: Waterborne Commerce of the U.S., Dept. of the Army, U.S. Corps of Engineers)

Year	Imports (1,000 Tons)
1962	12,613
1963	10,203
1964	14,039
1965	15,065
1966	15,509
1967	13,983
1968	10,582
1969	12,481
1970	12,768
1971	13,104
1972	10,044

TABLE 11

Forecast of Delaware River Iron Ore Imports: 1970 - 2025

Year	Imports (1,000 Tons)
1970	12,500
1980	14,100
1990	16,600
2000	17,500
2010	18,900
2020	19,500
2025	20,000

(Sources: 1970 - 2000, U. S. Department of the Army, Corps of Engineers, *Interim Report: Atlantic Coast Deepwater Port Facilities Study*, June 1973.

2001 - 2025, Tippetts-Abbett-McCarthy-Stratton.)

of Delaware River facilities are from the northern coast of South America, ore carriers are not amenable to the economies of scale offered by very large ships for trips greater than 6,000 miles. The predominant ship size range for vessels calling at Delaware River ports is the 50,000 - 55,000 DWT class, and this is not expected to change over the study period. This size vessel is also the largest that can be accommodated on the Delaware River north of Philadelphia. In 1970, there was a total of 710 ore vessel arrivals, and as shown in Table 12, this total is predicted to increase to approximately 1,130 by 2025.

SUMMARY

A summary of projected oil and iron ore vessel arrivals is given in Table 13 assuming a deepwater port is developed. Table 14 presents the projection of vessel traffic assuming no deepwater port is developed.

TABLE 12

Forecast of Delaware River Iron Ore Carrier Arrivals: 1970 - 2025

Year	Number of Vessels
1970	710
1980	820
1990	940
2000	990
2010	1,070
2020	1,110
2025	1,130

TABLE 13

Forecast of Delaware River Oil and Ore Vessel Traffic Assuming Deepwater Port

Year	Oil Tankers (less than 150,000 DWT)	Oil Barges	Ore Carriers	Total
1970	2051	---	710	2,761
1980	476	---	820	1,296
1990	380	---	940	1,320
2000	344	---	990	1,334
2010	394	---	1,070	1,464
2020	444	---	1,110	1,554
2025	469	---	1,130	1,599

TABLE 14

Forecast of Delaware River Oil and Ore Vessel Traffic Assuming No Deepwater Port

Year	Oil Tankers (less than 150,000 DWT)	Oil Barges	Ore Carriers	Total
1970	2050	---	710	2,760
1980	590	1505	820	2,915
1990	525	2200	940	3,665
2000	495	3220	990	4,705
2010	560	3380	1,070	5,010
2020	630	3920	1,110	5,660
2025	670	4140	1,130	5,940

CHAPTER 4

ANCHORAGE USE

GENERAL

The number of arrivals in 1972 at each anchorage for each purpose can be related to the total vessel traffic entering the anchorage from the data in Table B-3 of the questionnaire evaluation (see Appendix B). Therefore, the use of all anchorages for each projected year can be forecast on the basis of the expected total vessel traffic. This section is a summary of the anchorage traffic analysis performed for Marcus Hook, Mantua Creek, Deepwater and Reedy Point anchorages. No forecast of use was made for Port Richmond and Gloucester anchorages as a preliminary review indicated that no justification for improving these two anchorages exist. More discussion on this is presented later in the report.

1972 ANCHORAGE USE

The questionnaire evaluation was prepared in three separate categories, one each for tankers, dry bulk vessels and general cargo vessels. The tanker population accounted for in Table B-1 of the tabulation is only 67 per cent of the actual number of vessels (with drafts greater than 25 feet) reported in 1972 by the Corps of Engineers in Waterborne Commerce of the United States. Therefore, the anchorage information for tanker operations in Table B-3 of Appendix B was increased by a factor of 1.5 to reflect the sample size. The number of dry bulk vessel arrivals indicated in Table B-1 of Appendix B is about 38 per cent of the 1972 total, as reported by the Philadelphia Maritime Exchange. Therefore, a factor of 2.6 was applied to increase this category. Finally, the total number of general cargo vessels reported through completed questionnaires and contacts with shipping agents accounts for about half the actual 1972 number as reported by the Philadelphia Maritime Exchange. Thus, the questionnaire sample was expanded by a factor of 2.0 to reflect the actual number of general

cargo vessel arrivals. The actual 1972 vessel population consists of 1,879 tankers, 560 ore vessels, and 2,523 general cargo vessels. The expanded anchorage use for 1972 is shown in Table 15.

PROJECTED ANCHORAGE USE

Tanker, oil barge, ore vessel and general cargo vessel anchorage use were forecast independently and then summed to obtain the total projection. Anchorage use was forecast for traffic conditions expected both with and without a deepwater port off Delaware Bay. Table 16 shows the total use estimates projected for the life of the project assuming no anchorage improvements for Marcus Hook, Mantua Creek, Deepwater and Reedy Point anchorages.

Reedy Point Anchorage is located at the east end of the Chesapeake and Delaware (C and D) Canal and serves mainly as an emergency anchorage area for vessels using the Canal. Improvements are under way that will increase the controlling depth in the Canal from its present 27 feet to 35 feet, thereby increasing to 33 feet the draft of vessels that can use the Canal. No estimates are available on the increase in vessel traffic that will result from the improvement, but a study of vessel trips to Baltimore Harbor indicates that an increase of as many as 1,000 trips may occur. This would increase the present traffic by less than 50%. Assuming the usage of Reedy Point Anchorage is a function of traffic on the C and D Canal, a corresponding increase in use of Reedy Point Anchorage to 50 vessels per year would result. Since the Anchorage with its present dimensions can accommodate at least two vessels of the size that can use the Canal. there appears to be adequate capacity at Reedy Point Anchorage.

Deepwater Point Anchorage lies at the mouth of the Christina River and is used mostly by general cargo vessels destined for the Wilmington Marine T rminal. The results of our questionnaire indicate that only

TABLE 15

1972 Anchorage Use

Name of Anchorage	Total Number of Arrivals	NUMBER OF ARRIVALS BY REASON FOR ANCHORING								Number of Arrivals with Two Reasons	Number of Arrivals with Three Reasons
		Waiting for Flood Tide	Weather	Upriver Anchorages Occupied	Vessel Too Large for Upriver	Waiting for Berth	Lightering	Turnaround	Other		
Big Stone	500	105	13	2	115	45	389		10	192	18
Breakwater	968	634	42	18	2	307			52	60	3
Marcus Hook	386	15	4	4		79	125	170	8	15	2
Mantua Creek	458	40	6			348	72		26	31	2
Bombay Hook	4		4								
Deepwater	8	2		2		7	2			2	
Reedy Point	30	5	4	2		18	2		2		
Greenwich	1,161	4	2			1,146			10	2	
Port Richmond	1		2								
TOTAL	3,516	805	77	28	117	1,950	590	170	108	302	25

eight vessels used the anchorage in 1972. Discussions with local interests, however, indicate that some 100 vessels may have used the anchorage. Even if this high estimate were correct, however, no increase capacity of this anchorage would be justified. Since most vessels using the Wilmington Marine Terminal are general cargo vessels, the controlling depth in the anchorage of 35 feet appears adequate.

Discussions with pilots and other local shipping interests indicate that the bed of Deepwater Point anchorage is very soft and as a result anchors do not hold well. As a result of this, vessels must constantly be moved and re-anchored. The scope of this report does not include the study of soil conditions, therefore no further investigations were made of this problem.

Improving the anchorages would result in a redistribution of their use, as the improved anchorages would become accessible to vessels formerly too large to utilize them. Initially, therefore, certain assumptions were made concerning anchorage usage. Preliminary analysis had shown that the major benefit of improving the anchorages would be a reduction in accidents. This analysis also indicated that historically the overwhelming majority of accidents occurred in the Marcus Hook - Mantua Creek area. Since Reedy Point and Deepwater Point Anchorages appear to be adequate, it was assumed for the purpose of estimating future anchorage use that only Marcus Hook and Mantua Creek would be improved.

The projections of anchorage use with improvements to the anchorages were made on the basis of the reasons for which vessels anchored. Tankers, oil barges and ore vessels that would otherwise use a Delaware Bay anchorage while waiting for a berth or because they were too large for the upriver anchorages, would be able to use an improved upriver anchorage. Therefore, these anchorings were redistributed between Marcus Hook and Mantua Creek anchorages. Similarly, tankers and oil barges that would otherwise lighter at downriver anchorages were projected to lighter at the improved upriver anchorage closest to the cargo destination.

Table 16 presents the expected anchorage traffic from 1975 to 2025, estimated on the above basis.

The future use of Mantua Creek Anchorage will be effected by two developments planned for the east shore of the Delaware River adjacent to the Mantua Creek Anchorage. Tenneco is planning to develop a facility to receive Liquid Natural Gas (LNG), with vessels arriving at the rate of one every thirty hours. General American Transportation Corporation (GATX) is planning to build a petroleum storage facility adjacent to the Tenneco. The only vessel access to either of these facilities is through Mantua Creek Anchorage. The mere fact that vessels would have to traverse the Anchorage would reduce its effective capacity by one or possibly two positions, but the use of LNG vessels poses additional safety problems. In addition, preliminary plans for the facility indicate that the planned berthing facilities will extend into the authorized enlargement of the Mantua Creek Anchorage. These facilities will make the enlargement of the Anchorage more difficult and costly.

Our analysis of anchorage use and the need for anchorage improvements has been restricted to Marcus Hook, Mantua Creek, Deepwater and Reedy Island anchorages. However, our evaluation of the questionnaire responses indicated that Big Stone Beach anchorage in Delaware Bay is currently heavily used by large tankers lightering oil to reduce draft and distribute the cargo to multiple destinations, and that there was a possibility of future congestion resulting from increased demand. The Coast Guard and the Delaware River pilots indicated in our discussions with them that the problem was more immediate. In either event, the demand for anchorage space in Delaware Bay will continue to rise with the projected increase in oil importation by large tankers until at least 1980, continuing beyond 1980 if no deepwater port is constructed. Thus, there appears to be a need for studying the capacity and projected use of the Delaware Bay anchorages in addition to those anchorages considered in this report.

TABLE 16

Projection of Anchorage Use

1972-2025

	WITHOUT ANCHORAGE IMPROVEMENTS								WITH IMPROVEMENTS			
	MARCUS HOOK		MANTUA CREEK		DEEPWATER		REEDY POINT		MARCUS HOOK		MANTUA CREEK	
YEAR	With Deepwater Port	Without Deepwater Port	With Deepwater Port	Without Deepwater Port	With Deepwater Port	Without Deepwater Port	With Deepwater Port	Without Deepwater Port	With Deepwater Port	Without Deepwater Port	With Deepwater Port	Without Deepwater Port
1972	386	386	458	458	8	8	30	30	386	386	458	458
1975	476	476	567	567	4	4	31	31	546	546	1,007	1,007
1980	106	419	389	582	8	9	8	33	109	476	671	1,026
1985	98	480	409	645	3	4	7	38	98	549	707	1,141
1990	93	548	430	708	8	10	6	43	87	621	731	1,242
1995	85	639	439	776	4	6	5	50	83	737	752	1,373
2000	86	738	448	847	11	14	5	58	79	848	771	1,504
2005	87	757	466	873	4	7	6	60	85	873	805	1,558
2010	92	785	484	903	11	14	6	63	90	899	824	1,597
2015	98	840	496	948	4	7	7	67	96	971	849	1,681
2020	107	937	507	993	11	15	7	72	102	1,043	884	1,768
2025	112	967	519	1,042	11	15	7	77	107	1,098	888	1,837

CHAPTER 5

ANALYSIS OF BENEFITS

The benefits that would result from improving the anchorages can be divided into three categories: safety in terms of reduced accidents, reduced lightering costs, and benefits from increased operational efficiency. Each of these benefits are dealt with in detail in the following sections.

No attempt has been made to quantify loss that would occur as a result of personal injury and loss of life. A review of U.S. Coast Guard records indicates that no loss of life has occurred in at least the past eight years due to inadequate anchorages although a collision of two tankers in 1953 that was in part caused by inadequate anchorages resulted in the loss of nine lives.

ACCIDENT BENEFITS

General

A principal reason for developing anchorages on the Delaware River is to provide a safe haven for vessels steaming along the 100-mile segment of the Delaware River from the Delaware Bay to Philadelphia and beyond. The six Federally Authorized anchorages were originally proposed to ensure that vessels would be able to stop safely at intervals along the River if it became necessary, due to adverse weather conditions, mechanical failure or other emergencies. Another reason for providing adequate anchorages is that Federal law prohibits ships from anchoring in channels in such a way as to prevent passage of other vessels.

The existing facilities provide safe anchorages for vessels of 550 to 600 feet with drafts of less than 33 feet. However, the results of our questionnaire indicate that the majority of vessels using the upriver anchorages, mostly Marcus Hook and Mantua Creek, are tankers and ore vessels which are substantially larger than this. This raises a question of

safety in these two anchorages. Marcus Hook Anchorage is maintained to a depth of 40 feet for a width of 1,400 feet. Mantua Creek Anchorage has a controlling depth of 37 feet with a width of 1,400 feet.

Vessels with a length of 800 feet circumscribe a circle 2,300 feet in diameter when allowed to swing free at anchor. To avoid grounding when swinging at the changing of the tide, these vessels anchor close to the channel and frequently, swing into the channel. This procedure is both unsafe and illegal. A vessel steaming along the channel could strike an anchored vessel broadside and result in damage, injury or loss of life and if a tanker were involved, it could result in an oil spill.

Discussions with Delaware River pilots and U.S. Coast Guard officials indicate that they believe the anchorages to be unsafe for the size of vessels that now use them. The pilots indicate that vessels moving in the channel often must wait while a vessel anchored in either Marcus Hook or Mantua Creek Anchorage close to the channel swings on its anchor into the channel.

Ore vessels destined to the United States Steel Fairless works are committed to a trip of 40 miles after leaving Marcus Hook anchorage because the anchorages between Marcus Hook and Fairless, (Mantua Creek, Gloucester and Port Richmond) are not large enough for vessels of this size to anchor safely.

Incidence of Accidents

A review of the accident records of the U.S. Coast Guard for the Delaware River over the period 1960 to 1972 was made to determine the number of accidents that can be attributed to conditions at the anchorages. Table 17 lists all of the groundings and collisions that were reported in the Delaware River during this period that can be attributed to the lack of improved anchorages. During this 13-year period, 19 groundings and 32 collisions occurred for a total of 51 accidents.

TABLE 17

Collisions and Groundings in the Delaware River

Associated with Anchorages

(1960 - 1972)

Year	Groundings	Collisions	Total	Total Cost	Total Cost 1973 Dollars
1960	6	2	8	1,050	1,860
1961	0	5	5	1,199,000	2,040,000
1962	1	2	3	198,200	320,000
1963	1	4	5	135,000	210,000
1964	5	4	9	288,000	430,000
1965	0	2	2	50,000	71,000
1966	1	5	6	101,360	137,000
1967	1	1	2	485,000	630,000
1968	0	2	2	90,000	102,000
1969	0	2	2	19,000	22,500
1970	0	0	0	0	0
1971	3	3	6	27,500	30,000
1972	1	0	1	0	0
TOTAL	19	32	51		3,994,360

Source: United States Coast Guard

TABLE 18

Vessel Casualty Rates

(1968 - 1972)

Year	Total Vessel* Arrivals with Drafts Greater than 18 Feet	Vessels Involved** In Anchorage Related Casualties
1968	5,314	3
1969	5,026	4
1970	5,308	0
1971	4,744	7
1972	4,911	1
TOTAL	25,303	15

* Source: U.S. Department of the Army, Corps of Engineers - Waterbone Commerce Statistics, 1968-1972, Delaware River-Philadelphia to the Sea.

** Source: United States Coast Guard.

An investigation of the detailed accident reports from 1968 to 1972 (Table 18) reveals that of the eleven casualties involving fifteen vessels that occurred during this period, five were in or near the Marcus Hook Anchorage and five in or near the Mantua Creek Anchorage. Most of the groundings resulted from vessels swinging on the changing tide or dragging anchor to the shallow areas of the anchorages. Collisions involved moving vessels striking anchored vessels in the anchorage and at least one collision during the five-year period involved an anchored vessel swinging into the channel.

During the period from 1968 to 1972 there were 25,303 vessel arrivals to the Delaware River between Philadelphia and the Sea, with drafts greater than 18 feet, which includes most vessels that use the anchorages. This results in an accident rate of 0.0006 accidents related to anchorages for each vessel arrival. In order to evaluate the impact improving the anchorages will have on the anchorage related accident rate, it is necessary to relate the accident rate to anchorage usage. In 1972 there were 4,911 arrivals of vessels greater than 18 feet. At a rate of 0.0006 accidents per arrival, this results in an average rate of 2.95 accidents per year. Since ten of the eleven anchorage related accidents that occurred between 1968 and 1972 can be attributed to the lack of enlarged Marcus Hook and Mantua Creek Anchorages, a simple ratio was taken which resulted in an accident rate of 2.68 accidents per year at the 1972 level of vessel arrivals. Based on information derived from questionnaire responses, it was determined that approximately 800 vessels anchored at these two anchorages during 1972. Based on this anchorage usage and the accident rate discussed above, an accident rate of 0.0034 accidents per vessel arrival at these two anchorages was developed. This value was used as a basis for the anchorage related accident analysis that follows.

The statistics included in this report only reflect accidents up

to and including 1972. In December 1973 a major casualty occurred at Marcus Hook Anchorage involving three vessels. The accident resulted in two vessels grounding, and oil spill and damage cost estimated at $600,000. Because of the manner in which the accident benefits were developed, the inclusion of this accident would be consistent with the results of this study.

Cost of Accidents

Table 17 also lists the cost of accidents in terms of damage to vessels for the period from 1960 to 1972. This indicates that the total damage cost for accidents over this period was $3,994.360 in 1973 dollars.

Many of the vessels involved in casualties must be dry docked immediately to carry out the repairs. The loss of revenue during repair is not included in the direct damage cost estimates.

Statistics show that 20% of groundings involve immediate dry docking for repairs. At an average cost of 400 dollars per vessel hour, this results in a loss of $20,000 for the assumed two-day dry docking period. Since there were 19 groundings between 1960 and 1972, the total loss or revenue while vessels were dry docked is estimated at $80,000 for the period.

On the basis that two vessels are involved in each collision and 50% of the vessels involved in collisions require dry docking for an average of two days, the total loss of revenue while vessels were dry docked is estimated at $600,000 for the period from 1960 to 1972.

Therefore, the total cost of damage for the period from 1960 to 1972 is $4,674,360 in 1973 dollars. This is tabulated in Table 19.

If it is assumed that two vessels were involved in each collision, it is estimated that 83 vessels were involved in these accidents, which results in an average damage cost per vessel of $55,000. Since accident damage is expected to increase with the increase in vessel size, an average vessel damage cost of $60,000 was used in the computations.

TABLE 19

DAMAGE COST
1973 DOLLARS

1)	Direct Damage Cost	$ 3,994,360
2)	Delay due to Groundings	80,000
3)	Delay due to Collision	600,000
	Total Damage Cost	$ 4,674,360

Oil Spill Costs

In the last few years a great deal of concern has developed over the deteriorating quality of our environment and a large part of this concern has been directed toward oil spills as a polluter of our waters. As a result, consideration of the cost of oil spill cleanup is an essential element in analyzing vessel accident costs.

The cost of oil spill cleanup varies depending on the circumstances involved in the spill, the location and amount of the spill, wind and current conditions, the distance to shore and the speed at which cleanup operations are begun.

Due to the tide and current, oil spills occurring in the Delaware River, spread quickly along the shore and require cleanup operations. Depending on conditions at the time of the spill, it is estimated that the cost of cleanup varies between $1 and $10 per gallon spilled. Because of the closeness of vessels to shore a cleanup cost of $5.00 per gallon of oil spilled has been assumed in this analysis.

Estimation of the amount of oil spilled is difficult because of a lack of data and the numerous variables. A reliable study done concerning past oil spills was carried out by Porcelli et al. of the U.S. Coast

TABLE 20

Oil Spill Costs

Spill Range (Tons)*	Average Spill (Tons)*	Average Spill (Gallons)*	Percent of Spills This Range*	Weighted Average Cleanup Cost Per Oil Spill ***
to 150	70	21,000	63.47	$ 68,000
151 to 500	390	117,000	22.37	132,000
501 to 3,000	1,230	370,000	10.05	186,000
3,001 to 14,000	7,900	2,470,000	3.65	450,000
14,000 and up	30,000**	9,000,000	0.46	210,000
TOTAL	--	---	100.00	$ 1,046,000

* Source: Oil Spill Probabilities and Analysis of Environmental Controls, prepared by the United States Coast Guard.

** Reduced from 49,200 tons indicated in the U.S.C.G. study to account for the smaller tankers using the Delaware River.

*** Assumes cleanup cost at $5.00 per gallon of oil spilled.

Guard in which worldwide tanker casualties that occurred within 50 miles of shore during the years 1969 and 1970 were studied. During this period, a total of 1,416 tanker casualties occurred with 266, or almost one fifth of the incidents involving an oil spill. The probability distribution of various spill sizes that occurred during this period is shown in Table 20.

Multiplying this distribution by the average number of gallons spilled and \$5.00 per gallon results in an average cleanup cost of \$1,046,000 per accident for those accidents that result in spills. Since only 20% of tanker casualties involve oil spills, an average cleanup cost per tanker accident of \$210,000 was used. This cost does not include the cost of environmental damage, including fish, birds and other wildlife, and the damage to property along the river that may be affected by an oil spill. The detailed analysis of environmental effects is beyond the scope of this study but consideration is given to this in the sensitivity analysis presented in Chapter 7.

Summary of Accident Benefits

Future vessel casualty rates resulting from anchorage conditions are a function of vessel traffic, improvements to the anchorages, improvements in vessel design such as double hulls, and future developments in vessel traffic control systems (VTCS).

If a deepwater port is developed near the Delaware Bay, it will reduce vessel traffic moving on the Delaware River and, therefore, anchorage usage. This in turn will reduce the number of accidents and result in lower accident benefits that can be attributed to anchorage improvements.

If a vessel traffic control system (VTCS) is instituted on the Delaware River, it will have the effect of reducing accidents in the channel by improving the coordination of the movement of ships. Porcelli has estimated the potential reduction in accidents resulting from this system to be 50%.

However, it is questionable whether a VTCS will reduce accidents at this rate in anchorages, which are cuased by groundings and collisions at low speed. Therefore, it is felt that improved communications will reduce anchorage related accidents by 25%. For the purposes of this analysis, it was assumed that VTCS would be installed by 1980.

If all tanker vessels were built with double hull construction, Porcelli estimated it would reduce the oil spillage from tanker accidents by 75%. Since the changeover to double hulls would not occur immediately, it is assumed that the percentage of vessels with double hulled vessels would increase gradually from 1980 and that all tanker would have double hulls by 2025.

If a deepwater port is not constructed, it is estimated that the maximum benefits as a result of the reduction of accidents that can be attributed to the improvement of Marcus Hook Anchorage would be 6.1 million dollars. If a Vessel Traffic Control System (VTCS) is instituted on the Delaware River, the benefit would be reduced to 4.8 million dollars and if a VTCS is instituted along with the gradual incorporation of double hulled vessels, this benefit would be reduced to 4.0 million dollars. These values include the total benefit over the life of the project expressed in terms of present worth in 1973, using a discount rate of 5.5%.

If a deepwater port is constructed and is operational by 1980, the maximum accident benefits that could be attributed to the improvement of Marcus Hook Anchorage would be reduced to 1.5 million dollars. The introduction of the VTCS and double hull vessels would reduce this further to 1.3 million dollars expressed as present worth in 1973. A summary of the accident benefits that can be attributed to the enlargement of the Marcus Hook Anchorage are presented in the first three columns of tables 21 and 22.

The maximum accident benefit that can be attributed to the improvement of Mantua Creek Anchorage will occur if a deepwater port is not

TABLE 21

Marcus Hook Anchorage
Without Deepwater Port

Summary of Benefits

(Thousands of 1973 Dollars)

Year	ACCIDENT BENEFITS					TOTAL BENEFITS**		
	No Safety Improvement	With VTCS	With VTCS and Double Hull Vessels	Operational Efficiency Benefits	Lightering Benefits	No Safety Improvement	With VTCS	With VTCS and Double Hull Vessels
1975*	325	245	245	13	11	349	269	269
1980*	285	215	215	15	13	313	243	243
2000*	510	380	290	48	21	579	449	359
2025*	660	500	210	58	28	746	586	296
Present Worth 1973	6,120	4,770	3,980	600	260	6,980	5,630	4,840

* Annual Benefits
** Including Lightering and Operational Efficiency Benefits

TABLE 22

Marcus Hook Anchorage
With Deepwater Port

Summary of Benefits

(Thousands of 1973 Dollars)

	ACCIDENT BENEFITS					TOTAL BENEFITS**		
Year	No Safety Improvement	With VTCS	With VTCS and Double Hull Vessels	Operational Efficiency Benefits	Lightering Benefits	No Safety Improvement	With VTCS	With VTCS and Double Hull Vessels
1975*	325	325	325	13	11	349	349	349
1980*	70	55	55	15	4	89	74	74
2000*	50	40	35	17	2	69	59	54
2025*	70	50	25	19	1	90	70	45
Present Worth 1973	1,530	1,340	1,260	286	70	1,886	1,696	1,616

* Annual Benefits
** Including Lightering and Operational Efficiency Benefits

built. This benefit is estimated to be 3.8 million dollars. If a VTCS is instituted on the Delaware River by 1980, this is estimated to reduce the benefit to 2.9 million dollars and if both the VTCS and double hulled vessels are introduced, the 1973 Present Worth value of the accident benefit is estimated at 2.5 million dollars.

If a deepwater port is constructed and is operational by 1980, the maximum accident benefit that can be attributed to the improvement of Mantua Creek Anchorage will be reduced to 1.6 million dollars. The introduction of the VTCS and double hull vessels will reduce the potential benefits further to 1.2 million dollars. A summary of the accident benefits that can be attributed to the enlargement of Mantua Creek Anchorage are presented in the first three columns of tables 23 and 24.

BENEFITS DUE TO INCREASED OPERATING EFFICIENCY

The results of our questionnaire reveal that a number of vessels now anchoring in the Delaware Bay would prefer to use the upriver anchorages but are not able to because these anchorages are for some reason inadequate. If the upriver anchorages were improved, these vessels would most probably anchor upriver closer to their destination. In general, there does not seem to be any quantifiable benefit to anchoring in the upriver anchorages as opposed to the Delaware Bay in terms of operational efficiency, except for lightering. Communications between the terminal and ship in general allow a vessel to time its departure from Delaware Bay to arrive at the terminal when a berth is available. However, some vessels depend on a flood tide to steam upriver. If a vessel were forced to miss a flood tide, it could result in a large delay. If , however, the vessel were anchored in an upriver anchorage, the delay would be less severe. The remainder of this section deals with benefits associated with missing a flood tide.

Table B-9 of the questionnaire tabulation (see Appendix B) provides

TABLE 23

Mantua Creek Anchorage
Without Deepwater Port

Summary of Benefits

(Thousands of 1973 Dollars)

	ACCIDENT BENEFITS					TOTAL BENEFITS **		
Year	No Safety Improvement	With VTCS	With VTCS and Double Hull Vessels	Operational Efficiency Benefits	Lightering Benefits	No Safety Improvement	With VTCS	With VTCS and Double Hull Vessels
1975*	210	210	210	11	185	406	406	406
1980*	120	120	120	12	210	342	342	342
2000*	330	255	190	40	370	740	665	600
2025*	410	210	155	50	470	930	730	675
Present Worth 1973	3,750	2,935	2,490	494	4,550	8,794	7,979	7,534

* Annual Benefits
** Including Lightering and Operational Efficiency

TABLE 24

Mantua Creek Anchorage
With Deepwater Port

Summary of Benefits

(Thousands of 1973 Dollars)

	ACCIDENT BENEFITS					TOTAL BENEFITS**		
Year	No Safety Improvement	With VTCS	With VTCS and Double Hull Vessels	Operational Efficiency Benefits	Lightering Benefits	No Safety Improvement	With VTCS	With VTCS and Double Hull Vessels
1975*	210	210	210	11	190	411	411	411
1980*	80	60	60	12	100	192	172	172
2000*	80	60	55	14	30	124	104	99
2025*	100	75	55	16	45	161	136	116
Present Worth 1973	1,550	1,280	1,240	240	1,300	3,090	2,820	2,780

* Annual Benefits
** Including Lightering and Operational Efficiency

information on vessels that waited at the breakwater for a flood tide before proceeding upriver. The data indicates that approximately 3 per cent of the vessels anchoring at the breakwater while waiting for a berth missed at least one flood tide. The average anchoring time for these vessels was over 27 hours. Further, it was estimated that improving the upriver anchorages would save those vessels waiting for a berth an average of 12 hours. Using an average operating cost of $400 per vessel, a benefit of $4800 would be realized by each vessel missing at least one flood tide while waiting for a berth.

Based on the above assumptions it was estimated that the present worth of the benefits due to operational efficiency assuming no deepwater port would be $600,000 for Marcus Hook and $494,000 for Mantua Creek Anchorage. If a deepwater port is operational by 1980 this would be reduced to $286,000 for Marcus Hook and $240,000 for Mantua Creek Anchorage. These figures are presented in tables 21 to 24.

LIGHTERING BENEFITS *

When the anchorage nearest the destination of the lightered cargo is unavailable, or for some reason unusable, the lightered cargo must be transshipped a greater distance than otherwise, increasing the costs to the shipper and the public. The excess lightering costs attributable to unimproved anchorages were computed on the basis of the ton-miles that would have been saved had the lightering vessel been able to anchor at the

* Subsequent to the computation of lightering benefits, it was learned from correspondence with the U.S. Coast Guard that lightering is not officially allowed under current regulations at Marcus Hook and Mantua Creek Anchorages. Therefore, even though they would provide real benefits to the shipping community, they are not included in the benefit cost analysis presented in Chapter 7.

anchorage closest to the terminal to which the cargo is destined. Tables B-6 through B-8 of the questionnaire tabulation (see Appendix B) indicate both the cargo destination and the anchorage from which the cargo was lightered in 1972. The minimum lightering distances and potential mileage savings were determined from this data.

For each lightering operation, the mileage saved multiplied by the tonnage lightered yields the ton-miles saved in 1972. The total ton-miles saved at each anchorage divided by the total tonnage lightered from the respective anchorage results in a weighted average of the mileage per lightered ton that could be saved by using the optimal anchorage. The average savings multiplied by the total projected tonnage to be lighered from the anchorage results in the ton-miles saved for each anchorage over the forecast period.

The Corps of Engineers, in their economic analysis of the Atlantic Coast Deepwater Port Facilities Study, used a unit cost for lightering of $0.0060 per ton-mile. Applying this rate to the savings in ton-miles obtained by using the optimally located anchorage results in the total savings.

The benefits in the form of decreased lightering costs that will accrue as a result of improving Mantua Creek are over $4.5 million, assuming no deepwater port. In contrast, a savings estimated at $260,000 over the entire life of the project would be realized by improving Marcus Hook anchorage. The difference in the benefits assigned to Marcus Hook and Mantua Creek is explained by the fact that Marcus Hook is presently capable of handling deeper draft vessels than Mantua Creek, and is frequently used by vessels lightering cargo to the Mantua Creek vicinity. Improvement of Mantua Creek, then, would tend to draw users away from Marcus Hook.

The savings attributable to lightering are substantial. Based on information obtained from questionnaire responses, between 30 and

50% of these benefits are attributable to vessels lightering to reduce draft and, therefore, can be considered a navigation function. The remaining vessels are lightering because no berth is available or because this is their normal mode of operation, unloading cargo for distribution. Where the anchorages are used for a marine terminal rather than a navigation function, it is questionable whether the benefits are applicable.

CHAPTER 6

ESTIMATED COSTS OF ANCHORAGE IMPROVEMENTS

DESCRIPTION OF THE ALTERNATIVES

The improvement of the anchorages to their authorized dimensions was considered for four of the authorized anchorages; Marcus Hook, Mantua Creek, Deepwater and Reedy Point. Detailed benefits and costs estimates were not developed for Gloucester and Port Richmond anchorages as a brief review indicated that insufficient space is available in which to expand their area and as their depths are now sufficient to accommodate those vessels able to anchor within the present dimensions.

The estimated preliminary costs of improving Deepwater Point and Reedy Point anchorages were developed under the assumption that these anchorages would be dredged to their authorized dimensions. The costs for this were updated from the Corps of Engineers 1955 report and are presented in Tables 25 and 26. Since these costs far exceeded potential benefits of improvements to these anchorages, no further alternative improvement schemes were considered.

Four alternative schemes for improving Marcus Hook and Mantua Creek anchorages were developed considering the expected vessel traffic and operating characteristics of these vessels. The alternatives provide different means of accommodating the same number of vessels, as described below and illustrated in Figures 4 and 5.

Alternative 1

This alternative provides for dredging the anchorages to their authorized dimensions at a controlling depth of 40 feet with an allowance of two feet for overdepth.

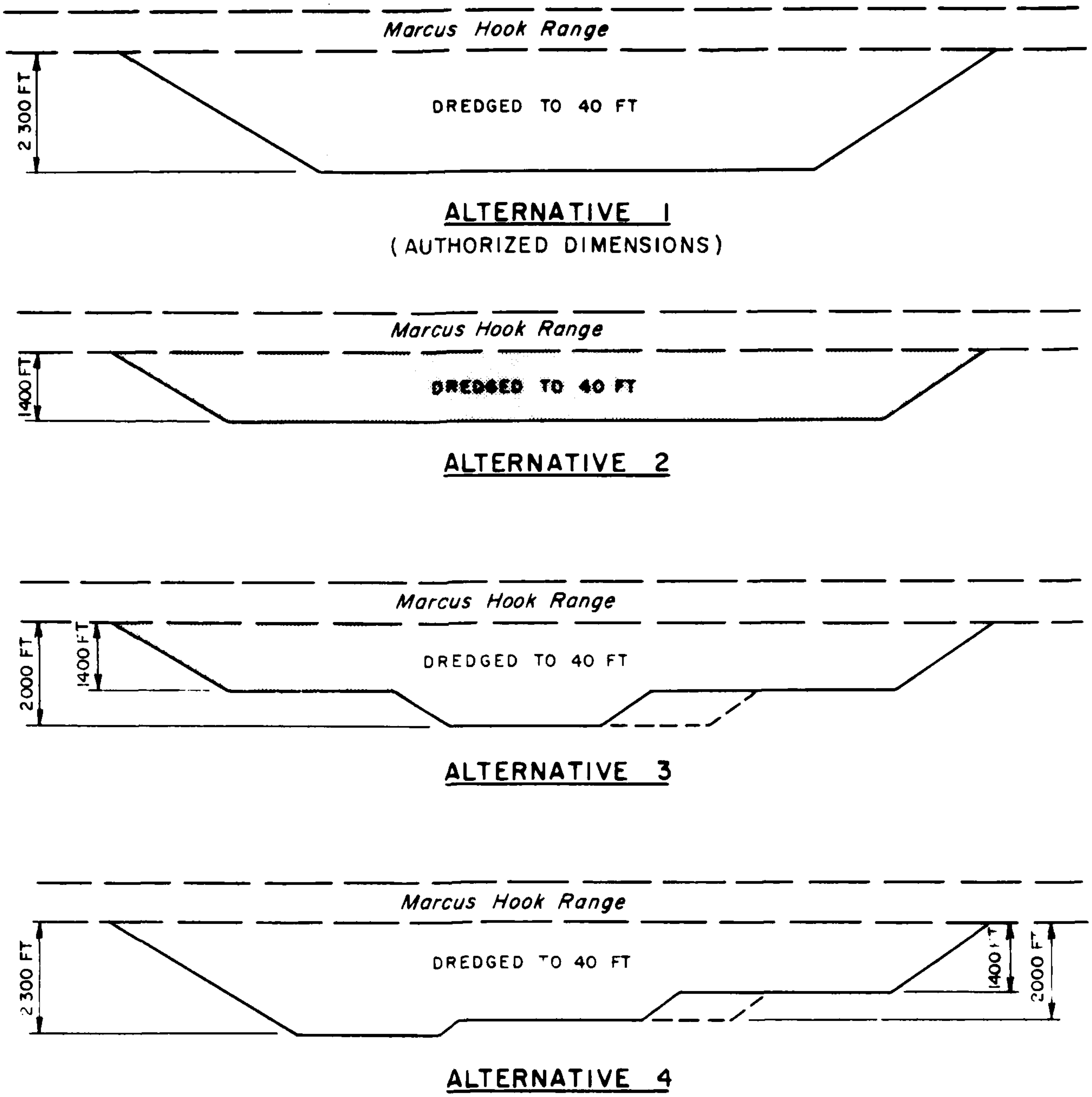
Alternative 2

Alternative 2 would require construction of conventional buoy moorings (CBM's) for each vessel position in the anchorages. This mooring system involves the use of four buoys to maintain a vessel in a given position and orientation, with the buoys generally arranged two astern and one on each side, and the ship's anchors holding the bow. Figure 6 illustrates a CBM system. While the CBM system requires approximately the same length (2,000 feet) of anchorage as a free swinging 800 foot vessel, it requires considerably less width, 1,400 versus 2,300 feet. Thus, this alternative requires dredging the anchorages to their authorized lengths and depths, but for a width of only 1,400 feet.

Alternative 3

In this alternative, CBM's would be installed in one section of each anchorage to handle the large oil tankers and ore vessels. The remainder of the anchorage would be dredged to less than the authorized dimensions to handle the smaller oil barges and general cargo vessels.

Improvement of the anchorages under this plan would be staged to reflect future increases in traffic volumes. Initially, CBM's would be constructed for two vessel moorings and two additional moorings would be dredged 40 feet deep for a width of 2,000 feet in each of the anchorages. The remaining unimproved sections of the anchorages would accommodate the projected general cargo vessel traffic. In 1990 one additional vessel anchorage area would be added to each anchorage by extending the portion of the anchorage dredged to 40 feet as is shown in Figures 4 and 5. This should eliminate any potential congestion that may result from the growth in oil barge traffic.



LEGEND

Mooring

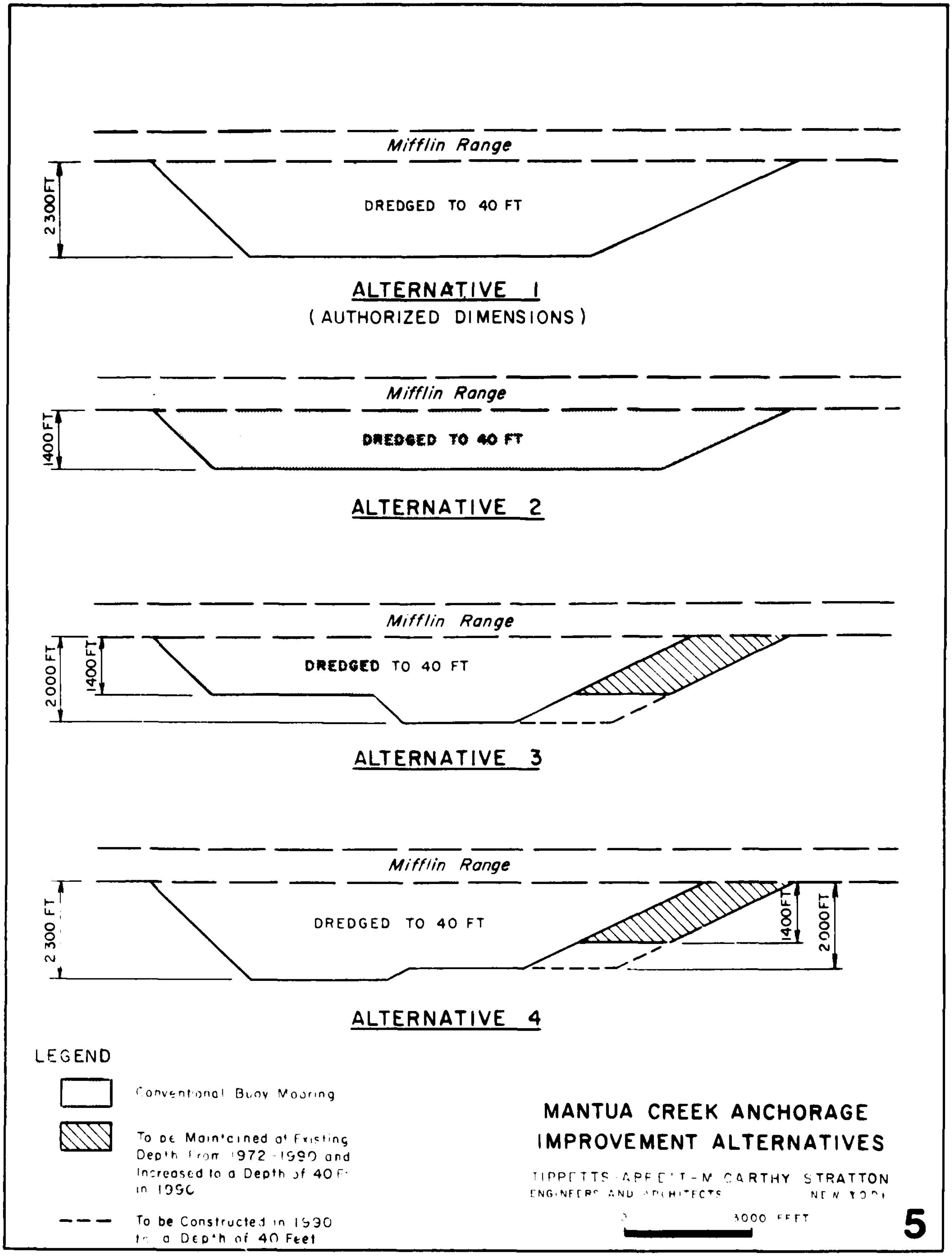
To be Constructed in 1990 to a Depth of 40 Feet

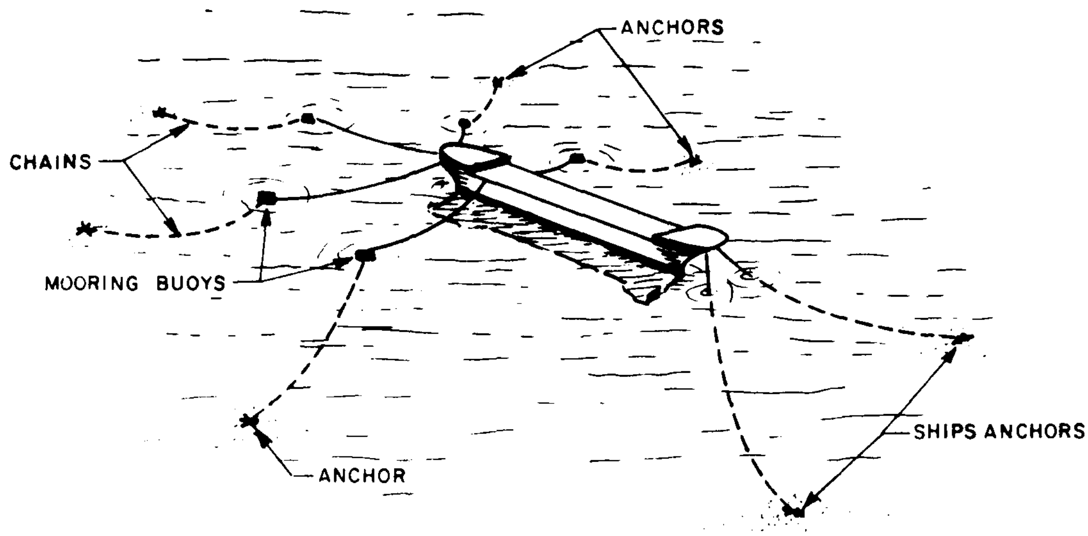
MARCUS HOOK ANCHORAGE IMPROVEMENT ALTERNATIVES

TIPPETTS-ABBETT-McCARTHY-STRATTON
ENGINEERS AND ARCHITECTS NEW YORK

0 3000 FEET

4


Mifflin Range
2300 FT
DREDGED TO 40 FT
ALTERNATIVE 1
(AUTHORIZED DIMENSIONS)
Mifflin Range
1400 FT
DREDGED TO 40 FT
ALTERNATIVE 2
Mifflin Range
2000 FT
1400 FT
DREDGED TO 40 FT
ALTERNATIVE 3
Mifflin Range
2300 FT
DREDGED TO 40 FT
1400 FT
2000 FT
ALTERNATIVE 4
LEGEND
Conventional Buoy Mooring
To be Maintained at Existing Depth From 1972-1990 and Increased to a Depth of 40 Ft in 1990
To be Constructed in 1990 to a Depth of 40 Feet
MANTUA CREEK ANCHORAGE
IMPROVEMENT ALTERNATIVES
TIPPETTS-ABBETT-McCARTHY-STRATTON
ENGINEERS AND ARCHITECTS NEW YORK
0 3000 FEET
5



ADAPTED FROM INTERIM REPORT, ATLANTIC COAST DEEP WATER PORT FACILITIES STUDY, U.S. ARMY CORPS OF ENGINEERS – PHILADELPHIA DISTRICT; NORTH ATLANTIC DIVISION

CONVENTIONAL BUOY MOORING (CBM)

TIPPETTS-ABBETT-McCARTHY-STRATTON
ENGINEERS AND ARCHITECTS NEW YORK

6

Alternative 4

This alternative is similar to Alternative 3, only in place of the section in which CBM's are constructed, the anchorage would be dredged to a width of 2,300 feet. The remaining portion of anchorage would be dredged to a 2,000 foot width, with construction staged as in Alternative 3.

DREDGING COSTS

Pursuant to our contract, the quantities of material to be dredged in Alternative 1 from Mantua Creek, Deepwater and Reedy Point were obtained from the Corps of Engineers' 1955 report. Dredging quantities for Marcus Hook, however, were recalculated from current soundings since Marcus Hook has been improved to its fully authorized dimensions and then allowed to silt up to its current dimensions. Therefore, improvement of Marcus Hook to tis authorized dimensions could be considered maintenance work. Similarly, dredging quantities for Alternatives 2, 3 and 4 were estimated on the basis of the proposed anchorage dimensions and current soundings.

Also in accordance with our agreement, the costs of preparing disposal areas, unit costs for dredging, and percentages for government costs and contingencies are based on the 1955 report. The lump sum costs in the 1955 report for the preparation of disposal areas included the cost of acquiring and diking these areas. All costs were escalated to 1973 dollars assuming an average annual increase since 1955 of 4.0 per cent. The order of magnitude of these costs were compared with recent bid prices for similar work and they appear reasonable except in the case of Mantua Creek Anchorage.

In the case of Mantua Creek Anchorage, the basis on which the costs were computed have changed. The costs presented in the 1955 report assume that spoil disposal areas are available within pipeline distance from this anchorage. This is not now the cast and the spoil will probably have to be barged to more distant disposal areas. Discussions

TABLE 25

Summary of Improvement Costs

(Without Deepwater Port)

Alternative Number	Anchorage	Total Dredging Costs*	Costs of Navigation Aids*	Pipeline Relocation Costs*	CBM Construction Costs*	CBM Operating Costs*	Total Maintenance Costs*	Total
1	Marcus Hook	$	$0.3				$6,370	$ 6,370,300
1	Mantua Creek	15,250	0.3	$650			2,740	18,640,300
1	Deepwater	5,800	0.3				3,960	9,760,300
1	Reedy Island	6,700	0.3				3,960	10,660,300
2	Marcus Hook		0.3		$6,000	$15,520		21,520,300
2	Mantua Creek	2,840	0.3	650	5,000	25,500	220	34,210,300
3	Marcus Hook		0.3		2,000	3,717	2,359	8,076,300
3	Mantua Creek	5,541	0.3	650	2,000	3,547	964	12,702,300
4	Marcus Hook		0.3				3,648	3,648,300
4	Mantua Creek	10,500	0.3	650			1,974	13,124,300

* Thousands of Dollars

TABLE 26

Summary of Improvement Costs

(With Deepwater Port)

Alternative Number	Anchorage	Total Dredging Costs*	Costs of Navigation Aids*	Pipeline Relocation Costs*	CBM Construction Costs*	CBM Operating Costs*	Total Maintenance Costs*	Total
1	Marcus Hook	$	$0.3				$6,370	$ 6,370,300
1	Mantua Creek	15,250	0.3	$ 650			2,740	18,640,300
1	Deepwater	5,800	0.3				3,960	9,760,300
1	Reedy Island	6,700	0.3				3,960	10,660,300
2	Marcus Hook		0.3		$6,000	$ 4,135		10,135,300
2	Mantua Creek	2,840	0.3	650	5,000	14,342	220	23,052,300
3	Marcus Hook		0.3		2,000	3,090	2,359	7,449,300
3	Mantua Creek	5,541	0.3	650	2,000	2,940	964	12,095,300
4	Marcus Hook		0.3				3,648	3,648,300
4	Mantua Creek	10,500	0.3	650			1,974	13,124,300

* Thousands of Dollars

with the Corps of Engineers indicates that the increased haul distance may result in increased dredging cost to $2.00 per cubic yard. No change, however, has been made in the cost since the improvement of Mantua Creek does not seem economically feasible using the lower cost and increasing the dredging cost would only make it less feasible.

The total dredging costs for each of the anchorages for all alternatives are shown in Table 25, without a deepwater port, and Table 26 with a deepwater port.

CAPITAL COSTS

In addition to dredging costs, Tables 25 and 26 present other investment costs assocated with the proposed anchorage expansions for establishing navigation aids, relocating pipelines and constructing CBM's. Cost estimates for these items were also based on the Corps' 1955 report and were escalated to 1973 dollars using an annual inflation rate of 4.0 per cent.

The costs of relocating or establishing new aids to navigation are estimated at $300 per anchorage.

The cost estimate for altering the location of one 8 inch and one 12 inch petroleum products pipeline to provide for an expanded Mantua Creek anchorage is $650,000. This cost would be borne by local interests.

The capital cost of constructing mooring buoys is estimated to be $250,000 each, or a cost of $1,000,000 per vessel mooring. Under Alternative 2, therefore, where all vessels would be required to use CBM's, the total CBM construction cost would be $6,000,000 for Marcus Hook and $5,000,000 for Mantua Creek. In Alternative 3, where only two vessels would use CBM's at each anchorage, estimated construction costs would be $2,000,000 each for Marcus Hook and Mantua Creek.

OPERATING COSTS

As vessels using CBM's require tug assistance and line handlers to make fast, there is in addition to the capital cost an annual operating cost associated with Alternatives 2 and 3. Based on information supplied by shipping interests to the Corps of Engineers during their 1968 study, escalated to 1973 dollars, tug costs are estimated at \$500 per vessel movement and line handling charges at \$250 per movement. As each call at an anchorage requires two vessel movements, operating costs are estimated to be \$1,500 per call.

As indicated in the previous discussion of projected vessel traffic, consideration of the possibility of a deepwater port facility being constructed off Delaware Bay yields two sets of CBM operating costs to reflect the separate traffic volumes expected under the two conditions.

The total operating costs were estimated by multiplying the expected number of vessel anchorings by \$1,500 and computing the present worth for each year of the project's life. The discounted annual costs were then summed to obtain the total operating cost at present worth for the 50-year life of the project. For this and other similar calculations, the project is assumed to be completed by 1975, and a discount rate of 5.5 per cent is used.

As shown in Table 25, the estimated operating costs of a CBM system in Marcus Hook anchorage, without a deepwater port, are \$15,520,000 and \$3,717,000 for Alternatives 2 and 3, respectively. In Mantua Creek, for the same condition, the operating costs are estimated at \$25,500,000 and \$3,547,000 respectively. With a deepwater port, the estimated operating costs are considerably reduced, being \$4,135,000 and \$3,090,000 respectively for Alternatives 2 and 3 in Marcus Hook and \$14,342,000 and \$2,940,000 respectively in Mantua Creek.

MAINTENANCE COSTS

Another cost associated with improving the Delaware River anchorages is the cost of the additional dredging required periodically to maintain the anchorages at their authorized depths. The quantities and unit costs of dredging used in computing the annual maintenance costs for Alternative 1 were taken from the Corps' 1955 report and escalated to 1973 dollars. The quantities of material expected to be dredged in maintaining the anchorages in Alternatives 2, 3 and 4 were based on the same proportion of maintenance to total dredging estimated for the anchorages in Alternative 1. While this is not necessarily a precise reflection of the natural siltation process, it was considered adequate for the purposes of this analysis. The same unit costs for each anchorage were used in all four alternatives.

The total maintenance costs for the 50 year life of the project were computed from the present worth of the annual costs. The total costs are indicated in Tables 25 and 26. It may be noted that Marcus Hook experiences the highest shoaling rate of the four anchorages, and has the highest estimated maintenance costs under each of the alternatives.

SUMMARY AND COMPARISON OF COSTS

The sum of dredging, capital, operating and maintenance costs for the condition without a deepwater port are presented in Table 25 and in Table 26 with a deepwater port. The total costs range from a high of approximately \$34.21 million for Mantua Creek under Alternative 2 to a low of about \$3.65 million for Marcus Hook under Alternative 4 without a deepwater port.

The high total cost of improving each anchorage under Alternative 2 indicates the high operating expenses associated with this alternative. [illegible] improvement costs are high for each anchorage in Alternative [illegible] dredging quantities which are involved. This is

particularly true in Mantua Creek, where the total cost is $18,640,000. Alternatives 3 and 4 attempt to minimize these high costs by designing the anchorages to meet specific vessel needs. By limiting the vessels using CBM's to only the larger ships, Alternative 3 results in reduced operational costs compared with Alternative 2. Under both Alternatives 3 and 4, the volume of dredging required is minimized by assuming that larger vessels would use only a particular section of each anchorage.

The lowest cost alternative for improving Marcus Hook anchorage is Alternative 4, with a total present worth cost of about $3.65 million. The next lower cost alternative is Alternative 1, estimated at $6.37 million.

The costs of Alternatives 3 and 4 for Mantua Creek are nearly the same, with Alternative 3 estimated at $12.70 million and Alternative 4 at $13.12 million. Although the total costs of the two alternatives are very close, it may be noted from Table 25 that the composition of the total costs is different. Under Alternative 4, all costs relate to dredging the anchorage and are Federal costs. Under Alternative 3, vessel operating costs associated with the CBM's which amount to 34 percent of the total costs would accrue to private shipping interests.

The construction of a deepwater port in Delaware Bay would not affect the costs of Alternatives 1 and 4. However, the reduction in vessel traffic in the Delaware River that would result from the development of a deepwater port would reduce the CBM operating costs associated with Alternatives 2 and 3. The total costs under the assumption that a deepwater port would be developed range from a high of $23.05 million for Mantua Creek in Alternative 2 to a low of $3.65 million for Marcus Hook in Alternative 4. The least cost alternative for Mantua Creek would be Alternative 3, at an estimated present worth of $12.10 million.

CHAPTER 7

COMPARISON OF BENEFITS AND COSTS

GENERAL

The benefits and costs of improving the federally authorized Delaware River anchorages under study were developed in chapters 5 and 6. This chapter compares these costs and benefits for each anchorage under two assumptions concerning the existence of a deepwater port. The analysis presents the effect on the benefit-cost ratio of safety improvements such as the Vessel Traffic Control System (VTCS) and the gradual incorporation of double hulled tankers into the fleet. The analysis also considers the sensitivity of the benefit-cost ratio to the costs of environmental damage. Benefits attributable to lightering are not included in this analysis since current regulations do not permit lightering from Marcus Hook and Mantua Creek Anchorages.

MARCUS HOOK ANCHORAGE

Table 27 presents a summary of benefits that can be expected if Marcus Hook Anchorage is improved, under the assumption that no deepwater port is built. The total benefits range from a high of $6,720,000 without safety improvements to a low of $4,580,000 if the VTCS is installed on the Delaware River and double hulled tankers are gradually incorporated into the fleet. Table 28 presents the costs of improving Marcus Hook anchorage under various alternatives. Alternative 4 which involves dredging the anchorage over a portion of the authorized dimension is the least cost solution with a total present worth cost of $3.65 million.

Based on these figures, a benefit-cost ratio of 1.84 would be realized if the VTCS is not installed and double hulled tankers do not come into wide spread use. If both these safety measures are incorporated, the benefit cost ratio would be reduced to an estimated 1.25.

TABLE 27

Summary of Benefits
(1975-2025)

Marcus Hook Anchorage

Without Deepwater Port

(Present Worth - 1973 Dollars)

Benefit	No Safety Improvements	VTCS	VTCS and Double Hull Tankers
Operational Efficiency	600,000	600,000	600,000
Accidents	6,120,000	4,770,000	3,980,000
Total	6,720,000	5,370,000	4,580,000

TABLE 28
Summary of Costs
(1975 - 2025)

Marcus Hook Anchorage

Without Deepwater Port

(Present Worth - 1973 Dollars)

Alternative	Public Cost	Private Cost	Total Cost
1. Full dredging	6,370,000	----	6,370,000
2. Full mooring buoys	6,000,000	15,520,000	21,520,000
3. Partial dredging and mooring buoys	4,360,000	3,720,000	8,080,000
4. Partial dredging	3,650,000	----	3,650,000

As was mentioned in Chapter 5, the cost in terms of environmental and property damage has not been included in the estimated cost of oil spills, nor has injury and death resulting from vessel accidents. The addition of these benefits would result in an increased benefit-cost ratio.

Table 29 presents the total benefits that would result from improving Marcus Hook anchorage if a deepwater port is developed. These benefits range from \$1.8 to \$1.6 million depending on assumptions concerning other safety improvements (VTCS and double hulled tankers). Estimated costs for each alternative are presented in Table 30. The lowest total cost among the alternatives would amount to \$3.65 million which is the same cost as that for the condition assuming a deepwater port is not built. Comparison of the benefits and costs, indicates a benefit cost ratio ranging from 0.44 to 0.49. If the costs of environmental and property damage amount to \$5.00 per gallon spilled or equal to the clean-up cost, the benefit cost ratio would increase to a range of from 0.64 to 0.73.

TABLE 29

Summary of Benefits
(1975 - 2025)

Marcus Hook Anchorage

With Deepwater Port

(Present Worth in 1973 Dollars)

Benefit	No Safety Improvements	VTCS	VTCS and Double Hull Construction
Operational Efficiency	290,000	290,000	290,000
Accidents	1,530,000	1,340,000	1,260,000
Total	1,820,000	1,630,000	1,550,000

TABLE 30

Summary of Costs
(1975 - 2025)

Marcus Hook Anchorage

With Deepwater Port

(Present Worth in 1973 Dollars)

Alternative	Public Cost	Private Cost	Total Cost
1. Full dredging	6,370,000	----	6,370,000
2. Full mooring buoys	6,000,000	4,140,000	10,140,000
3. Partial dredging and mooring buoys	4,360,000	3,090,000	7,450,000
4. Partial dredging	3,650,000	----	3,650,000

MANTUA CREEK ANCHORAGE

Table 31 presents the summary of benefits that can be expected if Mantua Creek Anchorage is improved assuming a deepwater port is not built. These benefits range from a high of $4.2 million to a low of $3.9 million, depending on whether the various safety improvements considered (VTCS and double hulled tankers) are implemented. The estimated costs associated with various alternative methods of improving Mantua Creek Anchorage are presented in Table 32. The total costs of alternatives 3 and 4 are almost the same, although the distribution between public and private sectors differ. Comparison of these costs with the benefits listed in Table 31 indicates a range of ratios from 0.30 to 0.32. If the costs of environmental damage and property damage amounted to $5 per gallon of oil spilled, it would increase the benefit resulting from reduced accidents to $5,850,000 for the situation in which no safety improvements are incorporated. This would in turn increase total benefits to $ 6,350,000 and would result in a benefit cost ratio of 0.65. If both the VTCS and double hull tankers were incorporated, the benefit cost ratio would be 0.58. It seems unlikely that a cost of greater than $5.00 per gallon spilled could be attributed to environmental damage, although insufficient evidence is available to support this judgement.

Table 33 indicates that if Mantua Creek Anchorage is built and a deepwater port is also constructed, the resultant benefits would range from $1.8 million to $1.5 million. The costs presented in Table 34 indicate the total costs of alternatives 3 and 4 to be almost equal. The benefit-cost ratio for improving Mantua Creek anchorage under this assumption ranges from 0.12 to 0.14 and the inclusion of environmental benefits is not likely to result in a positive benefit-cost ratio.

DEEPWATER POINT ANCHORAGE

The initial cost of dredging Deepwater Point Anchorage is estimated at $5.8 million. The calculation of the present worth of total estimated maintenance costs over the 50-year life of the project and addition

TABLE 31

Summary of Benefits

(1975 - 2025)

Mantua Creek Anchorage
Without Deepwater Port
(Present Worth in 1973 Dollars)

Benefit	No Safety Improvements	VTCS	VTCS and Double Hull Construction
Operational Efficiency	500,000	500,000	500,000
Accidents	3,750,000	2,935,000	2,490,000
Total	4,250,000	3,435,000	2,990,000

TABLE 32

Summary of Costs
(1975 - 2025)
Mantua Creek Anchorage

Without Deepwater Port
(Present Worth in 1973 Dollars)

Alternative	Public Cost	Private Cost	Total Cost
1. Full dredging	18,640,000	----	18,640,000
2. Full moving bouys	8,710,000	25,500,000	34,210,000
3. Partial dredging and moving bouys	9,160,000	3,550,000	12,710,000
4. Partial dredging	13,120,000	----	13,120,000

TABLE 33

Summary of Benefits

(1975 - 2025)

Mantua Creek Anchorage

With Deepwater Port

(Present Worth in 1973 Dollars)

Benefit	No Safety Improvements	VTCS	VTCS and Double Hull Construction
Operational Efficiency	240,000	240,000	240,000
Accidents	1,550,000	1,280,000	1,240,000
Total	1,790,000	1,520,000	1,480,000

TABLE 34

Summary of Costs

(1975 - 2025)

Mantua Creek Anchorage

With Deepwater Port

(Present Worth in 1973 Dollars)

Alternative	Public Cost	Private Cost	Total Cost
1. Full dredging	18,640,000	----	18,640,000
2. Full moving bouys	8,710,000		23,050,000
3. Partial dredging and moving bouys	9,160,000		12,100,000
4. Partial dredging	13,120,000	----	13,120,000

of this figure to initial dredging costs results in a total present worth cost of $9.8 million. Benefits that would result from improving this anchorage would be no more than one-tenth of this total construction and maintenance costs. Based on this relationship, no justification for improvement appears evident. The effect of a deepwater port or environmental benefit would not change this basic relationship significantly.

REEDY POINT ANCHORAGE

The total estimated cost of improving Reedy Point Anchorage including initial dredging and maintenance expressed in present worth terms is $10.7 million. The benefits that would accrue as a result of improving this anchorage in terms of increased operating efficiency and savings in accidents is estimated to be no more than one-third of this figure. As a result, there appears to be no justification for improving this anchorage at this time. The effect of a deepwater port or environmental benefits would not change this basic relationship significantly.

GLOUCESTER AND PORT RICHMOND ANCHORAGES

Based on discussions with local interests and a preliminary review of the results of the questionnaire there is no indication that improvements to these anchorages is justified or feasible. These anchorages cannot be expanded in size and their depths are adequate to handle the vessels now using them.

APPENDICES

APPENDIX A

SAMPLE QUESTIONNAIRE

TIPPETTS-ABBETT-McCARTHY-STRATTON

ENGINEERS AND ARCHITECTS

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EDWARD T. SANDS, C.P.A.

TAMS has been retained by the Philadelphia District of the Corps of Engineers to prepare engineering and economic analyses and a report on authorized Delaware River anchorages. Our work includes reporting present ship traffic, projecting future ship traffic, estimating the benefits associated with the anchorages, reviewing alternative plans for improving the anchorages, updating the costs of constructing the improvements and preparing cost-benefit analyses of the proposed improvements.

Special attention is being given to assessment of the benefits to be gained through improvement of the anchorages. In this connection, we enclose a questionnaire designed to elicit information on the use of Delaware River Anchorages.

Form No. 1 of the questionnaire requests detailed information concerning the movement and characteristics of all ships entering the Delaware River during the year 1972, whether they used the anchorages or not. This form is designed to indicate the nature of delays resulting from inadequate anchorages upriver. Please make certain that the date, company name, and compiler's name and telephone number are included at the top of the page. Include only arriving vessels in the questionnaire.

Form No. 2 requests detailed information concerning lightering from anchored vessels. If a vessel has lightered cargo bound for multiple destinations, please enter all the destinations in the columns provided.

Form No. 3 requests estimates of expected ship movements and fleet composition five and ten years in the future.

We should appreciate your returning the completed questionnaire to us as soon as possible, but not later than July 20, 1973.

Thank you for your cooperation. If you have any additional comments, please do not hesitate to include them.

Sincerely,

TIPPETTS-ABBETT-McCARTHY-STRATTON

Albert T. Rosselli

Enclosures

AD-A084 156 TIPPETTS-ABBETT-MCCARTHY-STRATTON NEW YORK F/G 13/10
ENGINEERING AND ECONOMIC ANALYSIS OF FEDERALLY AUTHORIZED DELAW--ETC(U)
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TIPPETTS-ABBETT-McCARTHY-STRATTON
ENGINEERS AND ARCHITECTS NEW YORK

PROJECT...DELAWARE RIVER ANCHORAGE STUDY

SUBJECT...Questionnaire Form No. 1

DATE......

COMPANY NAME...

COMPILED BY.....

TELEPHONE NO....

ANCHORAGE USAGE FOR THE YEAR 1972

Voyage Number	Vessel Name (Indicate registry after name by (F) if foreign or (D) if U.S.)	Vessel Type	Vessel Length	Vessel Draft	Date and Time of Arrival at B/W (See Note 1)	If anchored at Delaware Bay			Vessel Using Upriver Anchorages				Name of Preferred Anchorage (See Note 3)	Name of Berth or Terminal	Date and Time of Arrival at Berth
						Name of Anchorage	Reason for Anchoring (See Note 2)	Date and Time of Departure	Name of Anchorage	Date and Time of Arrival	Reason for Anchoring (See Note 2)	Date and Time of Departure			

Note 1: B/W Breakwater

Note 2: Reasons for anchoring. Indicate letter code in chart. One ship may have more than one reason for anchoring for example waiting for flood tide and upriver anchorages are fully occupied.

Letter Code

a) Wait for flood tide
b) Weather
c) Upriver anchorages fully occupied
d) Vessel too large to use upriver anchorage
e) Waiting for berth
f) Lightering, (if lightering fill in information required on form 2)
g) Other - Specify on separate sheet

Note 3: Indicate the name of the anchorage the vessel would have preferred using because of its geographical location. If the preferred anchorage was the one used, then leave blank.

TIPPETTS-ABBETT-McCARTHY-STRATTON
ENGINEERS AND ARCHITECTS NEW YORK

PROJECT...DELAWARE RIVER ANCHORAGE STUDY

SUBJECT...Questionnaire Form No. 2

LIGHTERING

Voyage Number	Name of Anchorage	Reason for Lightering (See Note 1)	Type of Cargo Lightered	Tonnage Lightered	Destination(s) of Lightered Cargo (See Note 2)			
					1	2	3	4

Note 1: Reasons for lightering - Indicate letter code in chart

Letter Code

a) To reduce draft
b) Berth not available
c) This is the typical mode of operation
d) Other - Specify on separate sheet

Note 2: Indicate name and location of berth or terminal.

TIPPETTS-ABBETT-McCARTHY-STRATTON
ENGINEERS AND ARCHITECTS NEW YORK

PROJECT...DELAWARE RIVER ANCHORAGE STUDY

SUBJECT...Questionnaire Form No. 3

PROJECTION OF ANNUAL PORT TRAFFIC

Year	Projected Number of Arrivals Assuming No Deepwater Port	% of Projected Arrivals			
		Less than 30' Draft (See Note 2)	30'-34'11" Draft	35'-38'6" Draft	Greater than 38'6" Draft
1972 (See Note 1)					
1977					
1982					

Note 1: Estimated present traffic

Note 2: Loaded salt water draft (summer)

APPENDIX B

RESULTS OF QUESTIONNAIRE

APPENDIX B

RESULTS OF QUESTIONNAIRE

DESCRIPTION OF COMPUTER CODES

VESSEL TYPE

Code	Description
01	Tanker
02	Dry Bulk
03	General Cargo
04	Barge

ANCHORAGE

01	Big Stone Beach
02	Breakwater (Brown Shoals)
03	Marcus Hook
04	Mantua Creek
05	Reedy Point
06	Kaighn Point
07	Bombay Hook
08	Deepwater Point
09	Reedy Island
10	Greenwich
11	Port Richmond

REASONS FOR ANCHORING

01	Waiting for flood tide
02	Weather
03	Upriver anchorages fully occupied
04	Vessel too large to use upriver anchorage
05	Waiting for berth
06	Lightering
07	Turnaround
08	Other

DESTINATION OR TERMINAL

Code	Description
001	Texaco - Eagle Point, N.J.
002	Greater Valley Terminal
003	Deepwater Point
004	Texaco - Claymont, Del.
005	Philadelphia, Pa.
006	Baltimore, Md.
007	Norfolk, Va.
008	Philadelphia Electric Company
009	Haab - Philadelphia, Pa.
010	New York City
011	Maine Electric
012	Massachusetts
013	Sun - Marcus Hook, Pa.
014	Texaco - Westville, N.J.
015	Getty - Delaware City, Del.
016	Gulf - Hog Island
017	Mantua Petroleum Terminal
018	BP - Marcus Hook, Pa.
019	Mobil - Paulsboro, N.J.
020	Arco - Fort Mifflin
021	Phillips - Gloucester, N.J.
022	BP - Paulsboro, N.J.
023	Hess - Delair, N.J.
024	Gulf - Girard Point
025	Transfer to another vessel
026	Exxon - Billingsport, N.J.
027	Cononco
028	Du Pont - Gibbstown, N.J.
029	Monsanto - Bridgeport, N.J.
030	Pier 55
031	Pier 96
032	Tioga Marine Terminal
033	Holts Marine Terminal
034	Pier 179 N.
035	Cities Service - Petty Island
036	Sico Terminal - Wilmington, Del.
037	Delaware River Terminal
038	Camden Marine Terminal
040	U.S. Steel - Fairless, Pa.

Code	Description
041	Pier 122
042	Pier 14
043	U.S. Gypsum
044	Pier 80 S.
045	Destination Unknown

TABLE B-1

Vessel Population

Vessel Draft

Vessel Type	LT 30	31-35	36	37	38	39	40	41-45	GT 45	Unknown	Total
1	162	279	173	150	131	150	71	120	39	0	1275
2	17	40	29	46	10	64	8	0	0	0	214
3	637	48	5	7	6	2	0	0	0	0	705
4	0	0	0	0	0	0	0	0	0	0	0
TOTALS	816	367	207	203	147	216	79	120	39	0	2194

Note: Responses received after September 15 were added to computer output and are shown here.

TABLE B-2

Arrivals by Month and Vessel Type

Month	Tanker	Dry Bulk	Gen. Cargo	Barge	Total
1	110	10	58	0	178
2	115	15	48	0	178
3	135	14	44	0	193
4	91	21	54	0	166
5	92	21	69	0	182
6	84	18	59	0	161
7	92	15	57	0	164
8	97	25	73	0	195
9	107	17	60	0	184
10	120	9	67	0	196
11	117	27	64	0	208
12	119	22	52	0	193
TOTALS	1279	214	705	0	2198

Note: Responses received after September 15 were added to computer output and are shown here.

TABLE B-3

Anchorage Usage

Anchorage Number	Number of Arrivals	Reasons for Anchoring								Two Reasons	Three Reasons
		1	2	3	4	5	6	7	8		
1	300	70	9	1	77	30	258	0	7	128	12
2	493	311	23	9	1	157	0	0	25	30	2
3	252	10	3	3	0	48	83	113	4	10	1
4	246	26	1	0	0	176	51	0	13	19	1
5	0	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0	0	0
7	3	0	3	0	0	0	0	0	0	0	0
8	3	1	0	1	0	1	1	0	0	1	0
9	21	2	3	1	0	13	1	0	1	0	0
10	208	2	1	0	0	202	0	1	3	1	0
11	1	0	1	0	0	0	0	0	0	0	0
12	0	0	0	0	0	0	0	0	0	0	0
13	0	0	0	0	0	0	0	0	0	0	0
14	0	0	0	0	0	0	0	0	0	0	0
15	0	0	0	0	0	0	0	0	0	0	0
TOTALS	1527	422	44	15	78	627	394	114	53	189	16

Note: Responses received after September 15 were added to computer output and are shown here.

TABLE B-3
Anchorage Usage
(Continued)

ANCH NO.	LT 1	1- 2	2- 3	3- 4	4- 5	5- 6	6- 7	7- 8	8- 9	9-10	10-11	11-12	GT-12	TOT AVG	AVG GT-12
							TIME IN ANCHORAGE (HOURS)								
1	1.	2.	2.	4.	3.	6.	5.	8.	5.	5.	8.	5.	244.	45.	55.
2	2.	6.	18.	25.	32.	31.	35.	38.	35.	29.	28.	15.	169.	5.	37.
3	113.	5.	3.	3.	3.	4.	0.	2.	5.	4.	8.	6.	92.	12.	35.
4	3.	7.	6.	6.	10.	8.	0.	10.	2.	6.	10.	4.	90.	18.	28.
5	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
6	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
7	0.	0.	0.	0.	0.	0.	0.	1.	0.	0.	1.	1.	0.	9.	0.
8	0.	0.	1.	0.	0.	0.	0.	0.	0.	0.	1.	0.	1.	9.	16.
9	1.	2.	1.	4.	0.	4.	3.	0.	2.	1.	0.	1.	1.	5.	14.
10	0.	2.	0.	0.	1.	1.	0.	2.	0.	0.	0.	0.	2.	64.	243.
11	0.	0.	0.	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.	3.	0.
12	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
13	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
14	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
15	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

TABLE B-4

DISTRIBUTION OF STEAMING TIME FROM BREAKWATER TO UP RIVER ANCHORAGE
NO. OF VESSELS IN EACH CATEGORY

ANCH NO.	LT 1	1- 2	2- 3	3- 4	4- 5	5- 6	6- 7	7- 8	8- 9	9-10	10-11	11-12	GT-12	TOT AVG	AVG GT-12
1	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
2	0.	2.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.	0.
3	2.	2.	0.	4.	29.	84.	68.	28.	4.	7.	3.	2.	15.	8.	50.
4	3.	0.	1.	2.	1.	18.	46.	53.	13.	5.	5.	4.	11.	16.	155.
5	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
6	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
7	0.	0.	0.	1.	1.	0.	1.	0.	0.	0.	0.	0.	0.	4.	0.
8	0.	0.	0.	0.	0.	2.	0.	1.	0.	0.	0.	0.	0.	5.	0.
9	0.	1.	3.	4.	7.	2.	0.	0.	0.	0.	0.	0.	2.	10.	66.
10	0.	0.	0.	0.	0.	1.	4.	2.	0.	0.	0.	0.	1.	8.	18.
11	0.	0.	0.	0.	0.	0.	0.	1.	0.	0.	0.	0.	0.	7.	0.
12	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
13	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
14	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
15	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

TABLE B-5

DISTRIBUTION OF STEAMING TIME FROM BREAKWATER TO UPRIVER ANCHORAGE
FOR THOSE VESSELS WHO LIGHTERED FROM THE UPRIVER ANCHORAGE

ANCH NO.	LT 1	1- 2	2- 3	3- 4	4- 5	5- 6	6- 7	7- 8	8- 9	9-10	10-11	11-12	GT-12	TOT AVG	AVG GT-12
1	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
2	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
3	0.	0.	0.	1.	3.	25.	19.	13.	3.	6.	3.	1.	9.	8.	21.
4	3.	0.	1.	2.	0.	4.	14.	12.	6.	2.	1.	1.	5.	8.	32.
5	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
6	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
7	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
8	0.	0.	0.	0.	0.	1.	0.	0.	0.	0.	0.	0.	0.	5.	0.
9	0.	0.	0.	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.	3.	0.
10	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
11	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
12	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
13	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
14	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
15	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

TABLE B-6

NUMBER OF SHIPS LIGHTERING FOR THE REASON
A REDUCE DRAFT
TONNAGE LIGHTERED BY TERMINAL AND ANCHORAGE

TERM NO	ANCH (1) NO. SHP	ANCH (1) TONNAGE LIGHTER	ANCH (2) NO. SHP	ANCH (2) TONNAGE LIGHTER	ANCH (3) NO. SHP	ANCH (3) TONNAGE LIGHTER	ANCH (4) NO. SHP	ANCH (4) TONNAGE LIGHTER	ANCH (5) NO. SHP	ANCH (5) TONNAGE LIGHTER	ANCH (6) NO. SHP	ANCH (6) TONNAGE LIGHTER	ANCH (7) NO. SHP	ANCH (7) TONNAGE LIGHTER	ANCH (8) NO. SHP	ANCH (8) TONNAGE LIGHTER	ANCH (9) NO. SHP	ANCH (9) TONNAGE LIGHTER	ANCH (10) NO. SHP	ANCH (10) TONNAGE LIGHTER
1	5.	205[illegible].	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
2	6.	512.	0.	0.	1.	70.	1.	27.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
3	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
4	7.	569.	0.	0.	2.	590.	0.	0.	0.	0.	0.	0.	0.	0.	1.	650.	0.	0.	0.	0.
5	30.	3305.	0.	0.	24.	2116.	9.	496.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
6	11.	1089.	0.	0.	12.	771.	4.	235.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
7	11.	802.	0.	0.	4.	528.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
8	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
9	0.	0.	0.	0.	0.	0.	1.	27.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
10	1.	6.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
11	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
12	0.	0.	0.	0.	1.	143.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
13	4.	312.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
14	35.	3842.	0.	0.	1.	7.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
15	46.	4119.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
16	27.	1491.	0.	0.	0.	0.	1.	52.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
17	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
18	3.	24[illegible].	0.	0.	1.	26.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
19	24.	2409.	0.	0.	0.	0.	1.	28.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
20	3.	146.	0.	0.	2.	178.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
21	0.	0.	0.	0.	0.	0.	1.	34.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
22	0.	0.	0.	0.	1.	18.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
23	0.	0.	0.	0.	0.	0.	1.	3.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
24	0.	0.	0.	0.	0.	0.	9.	436.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
25	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
26	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
27	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
28	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
29	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
30	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
31	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
32	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
33	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
34	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
35	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
36	0.	0.	0.	0.	2.	85.	3.	267.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
37	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
38	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
39	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
40	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
41	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
42	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
43	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
44	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
45	0.	0.	0.	0.	0.	0.	2.	134.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
46	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
47	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
48	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
49	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
50	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
TOTAL	192.	20871.	[illegible]	[illegible]	37.	4534.	29.	1740.	0.	0.	0.	0.	0.	0.	1.	650.	0.	0.	0.	0.

**** TONNAGE GIVEN IN 100 TONS

TABLE B-7

NUMBER OF SHIPS LIGHTERING FOR THE REASON
B BERTHS NOT AVAILABLE
TONNAGE LIGHTERED BY TERMINAL AND ANCHORAGE

TERM NO	ANCH (1) NO. SHP	ANCH (1) TONNAGE LIGHTER	ANCH (2) NO. SHP	ANCH (2) TONNAGE LIGHTER	ANCH (3) NO. SHP	ANCH (3) TONNAGE LIGHTER	ANCH (4) NO. SHP	ANCH (4) TONNAGE LIGHTER	ANCH (5) NO. SHP	ANCH (5) TONNAGE LIGHTER	ANCH (6) NO. SHP	ANCH (6) TONNAGE LIGHTER	ANCH (7) NO. SHP	ANCH (7) TONNAGE LIGHTER	ANCH (8) NO. SHP	ANCH (8) TONNAGE LIGHTER	ANCH (9) NO. SHP	ANCH (9) TONNAGE LIGHTER	ANCH (10) NO. SHP	ANCH (10) TONNAGE LIGHTER
1	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
2	1.	6[illegible].	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
3	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
4	1.	6[illegible].	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
5	0.	0.	0.	0.	5.	540.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
6	0.	0.	0.	0.	4.	430.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
7	0.	0.	0.	0.	3.	250.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
8	0.	0.	0.	0.	1.	50.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
9	0.	0.	0.	0.	1.	50.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
10	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
11	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
12	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
13	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
14	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
15	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
16	1.	933.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
17	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
18	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
19	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
20	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
21	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
22	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
23	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
24	0.	0.	0.	0.	0.	0.	2.	385.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
25	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
26	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
27	0.	0.	0.	0.	1.	13.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
28	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
29	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
30	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
31	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
32	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
33	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
34	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
35	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
36	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
37	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
38	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
39	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
40	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
41	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
42	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
43	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
44	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
45	0.	0.	0.	0.	0.	0.	1.	17.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
46	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
47	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
48	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
49	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
50	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
TOTAL	2.	1053.	0.	0.	7.	1332.	3.	402.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

**** TONNAGE GIVEN IN 100 TONS

TABLE B-8

NUMBER OF SHIPS LIGHTERING FOR THE REASON
C NORMAL OPERATION
TONNAGE LIGHTERED BY TERMINAL AND ANCHORAGE

TERM NO	ANCH (1) NO. SHP	ANCH (1) TONNAGE LIGHTER	ANCH (2) NO. SHP	ANCH (2) TONNAGE LIGHTER	ANCH (3) NO. SHP	ANCH (3) TONNAGE LIGHTER	ANCH (4) NO. SHP	ANCH (4) TONNAGE LIGHTER	ANCH (5) NO. SHP	ANCH (5) TONNAGE LIGHTER	ANCH (6) NO. SHP	ANCH (6) TONNAGE LIGHTER	ANCH (7) NO. SHP	ANCH (7) TONNAGE LIGHTER	ANCH (8) NO. SHP	ANCH (8) TONNAGE LIGHTER	ANCH (9) NO. SHP	ANCH (9) TONNAGE LIGHTER	ANCH (10) NO. SHP	ANCH (10) TONNAGE LIGHTER
1	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
2	3.	264.	0.	0.	2.	153.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
3	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
4	3.	280.	0.	0.	2.	180.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
5	14.	1885.	0.	0.	19.	2516.	2.	61.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
6	7.	629.	0.	0.	7.	780.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
7	6.	49[illegible].	0.	0.	8.	802.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
8	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
9	0.	0.	0.	0.	1.	50.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
10	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
11	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
12	0.	0.	0.	0.	1.	143.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
13	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
14	3.	28[illegible].	0.	0.	1.	7.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
15	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
16	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
17	0.	0.	0.	0.	0.	0.	2.	414.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
18	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
19	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
20	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
21	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
22	1.	8[illegible].	0.	0.	0.	0.	1.	90.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
23	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
24	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
25	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
26	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
27	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
28	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.	15.	0.	0.
29	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
30	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
31	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
32	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
33	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
34	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
35	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
36	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
37	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
38	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
39	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
40	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
41	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
42	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
43	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
44	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
45	0.	0.	0.	0.	0.	0.	2.	142.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
46	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
47	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
48	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
49	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
50	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
TOTAL	23.	39[illegible]0.	0.	[illegible]	25.	4633.	7.	707.	0.	0.	0.	0.	0.	0.	0.	0.	1.	15.	0.	0.

**** TONNAGE GIVEN IN 100 TONS

TABLE B-9

VESSELS ANCHORING WHILE WAITING FOR FLOOD TIDE
NOT INCLUDING SHIPS THAT LIGHTERED ALSO

ANCHORAGE NO.	NO.SHIPS ANCHORING	VESSEL TYPES TANKER	DRY BULK	GEN CARGO	OTHER
1	31.	31.	0.	0.	0.
2	291.	174.	117.	0.	0.
3	8.	7.	1.	0.	0.
4	14.	13.	1.	0.	0.
5	0.	0.	0.	0.	0.
6	0.	0.	0.	0.	0.
7	0.	0.	0.	0.	0.
8	1.	0.	1.	0.	0.
9	2.	2.	0.	0.	0.
10	1.	0.	1.	0.	0.
11	0.	0.	0.	0.	0.
12	0.	0.	0.	0.	0.
13	0.	0.	0.	0.	0.
14	0.	0.	0.	0.	0.
15	0.	0.	0.	0.	0.

TIME IN ANCHORAGE(HOURS)

ANCH NO.	LT 1	1- 2	2- 3	3- 4	4- 5	5- 6	6- 7	7- 8	8- 9	9-10	10-11	11-12	GT-12	TOT AVG	AVG GT-12
1	0.	1.	2.	4.	2.	3.	2.	3.	1.	1.	3.	1.	8.	9.	19.
2	1.	5.	16.	20.	29.	29.	32.	31.	33.	23.	22.	9.	41.	9.	28.
3	0.	0.	0.	0.	1.	2.	0.	0.	1.	0.	0.	0.	4.	23.	42.
4	1.	3.	2.	0.	1.	2.	0.	3.	0.	0.	0.	1.	1.	5.	12.
5	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
6	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
7	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
8	0.	0.	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	2.	0.
9	0.	0.	1.	0.	0.	1.	0.	0.	0.	0.	0.	0.	0.	3.	0.
10	0.	0.	0.	0.	0.	0.	0.	1.	0.	0.	0.	0.	0.	7.	0.
11	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
12	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
13	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
14	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
15	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

APPENDIX C

CONCERNS RESPONDING TO QUESTIONNAIRE

APPENDIX C

CONCERNS RESPONDING TO QUESTIONNAIRE

American Mail Line Ltd.

Amoco Shipping Company

Atlantic Richfield Company

BP Oil Corporation

Calmar Steamship Corporation

Cities Service Tankers Corporation

Delta Steamship Lines, Inc.

Express Marine, Inc.

Exxon Company, U.S.A.

Farrell Lines Inc.

Getty Oil (Eastern Operations), Inc.

Gulf Oil Company

Interstate Oil Transport Co.

Keystone Shipping Company

Charles Kurz Co.

Lavino Shipping Company

S.C. Loveland Co., Inc.

Lykes Bros. Steamship Co., Inc.

Marine Transport Lines, Inc.

Mobil Oil Corporation

National Bulk Carriers

Norton, Lilly & Co., Inc.

Pacific Far East Lines

E.I. du Pont de Nemours & Co., Inc.

Prudential - Grace Lines, Inc.
Reynolds Metals Company
Scott Paper Company
Sea-Land Service, Inc.
States Steamship Company
Stockyard Shipping & Terminal Co.
Sun Transport, Inc.
Texaco, Inc.
Texas Transport and Terminal Co.
United States Lines, Inc.
C.G. Willis, Inc.
T.A. McCarthy, Inc.

APPENDIX D

PERSONS CONTACTED

APPENDIX D

PERSONS CONTACTED

A. Corps of Engineers

Mr. Louis Caccese
Chief, Operations Division, Philadelphia District

Mr. Ronald Kreh
Assistant Chief, Operations Division, Philadelphia District

Mr. Robert Kaighn
Project Manager, Philadelphia District

Mr. Myron Yuschishin
Corps of Engineers, Philadelphia District

B. United States Coast Guard

R.I. Price, Captain, USCG
Captain of Port of Philadelphia

Commander T. Seaman, USCG

Commander W.H. Simpson, USCG
Marine Inspection Department

C. Shipping Industry

Mr. H.W. Jackson, President
Philadelphia Maritime Exchange
Chairman of the Joint Executive Committee for the Improvement and Development of the Philadelphia Port Area

Mr. William Harrison, Secretary
Philadelphia Maritime Exchange

Mr. Paul Hammer, Executive Director
American Institute of Merchant Shipping

Mr. Samuel Schellenger, President
Pilots Association of the Bay and River Delaware

Captain T. Rowland Marshall, Past President
Pilots Association for the Bay and River Delaware

Mr. Harry Rowland
Wilmington Marine Terminal Pilot

Mr. Harry Fisher, Deputy Director and Secretary
Philadelphia Port Corporation

Ms. Doris Dawson, Port Director
Wilmington Marine Terminal

Mr. Joseph F. Casella, Port Engineer
Wilmington Marine Terminal

Mr. Robert H. Mathers, Eastern Regional Manager
General American Transportation Company

Mr. David L. Moyer, Project Manager
General American Transportation Company

Mr. J.H. Merrell
Texaco, Inc.

Mr. R.J. Smith
GOTCO

Captain Diego Batista
Norton Lilly & Co.

Mr. G.C. Bradford, Agents' Comm.
R.M.T.A.

Mr. J.A. Pieray
Exxon Company

Mr. M.A. Searles
Mobil Oil Company

Mr. G.M. Richards
ARCO

Mr. T. O'Connor
National Bulk Carriers, Inc.

D. <u>Others</u>

Mr. David Stith, President
Underwater Technics Inc.

Mr. Maylin Greaser, President
American Dredging Company

Captain H.L. Lusk (Retired), USCG
Consultant to TENNECO

Dr. Walter Boyer, Deputy Administrator
Maryland Port Administration

APPENDIX E

REFERENCE LITERATURE

APPENDIX E

REFERENCE LITERATURE

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